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CONTENTS.

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THE WHEATS OF BALUCHISTAN, KHORASAN AND THE KURRAM VALLEY.

BY

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THE WHEATS OF BALUCHISTAN.

I. INTRODUCTION.

In 1909, the subject of the improvement of wheat cultivation in this Agency was taken up in response to a request from the Revenue Commissioner of Baluchistán. In order to obtain some knowledge of the varieties of wheat grown, samples of ripe ears, together with details of the cultivation, were sent from each District. These wheats present several interesting features from the systematic standpoint, and from the point of view of the distribution of varieties in India on account of the proximity of Baluchistán to Central Asia—the source of so many immigrations into India and the probable original home of the wheat plant of antiquity. A careful examination and classification of the wheats of this region has therefore been made and this forms the subject of the present paper. Some account of the cultivation has also been included as the agricultural and climatic conditions of Baluchistán are to some extent unique and are very different from those of India.

The country of Baluchistán forms a transition between the plains of India and the elevated plateaux and mountain systems of Central Asia. It includes the plains of Nasírábád, Sibi and Kachhi (which resemble Sind in almost all respects) and high valleys such as that of Quetta, five thousand feet above the sea and the Toba plateau, the elevation of which is seven thousand feet. The Agency includes Districts directly under British administration and also territory which is under political control only, such as the States of Kalát and Las Bela. The range in altitude and climatic conditions is very great.

Generally speaking, only a small part of the Agency consists of plains, some of low elevation—such as those of Nasírábád and Sibi, the Kachhi plain in Kalát and the littoral of Makrán and Las Bela—and some at higher altitudes such as the Toba and Chaman plains and the Dák in Chágai. By far the largest part consists of ranges of mountains, sometimes of great altitude, intersected by long narrow valleys. Cultivation is restricted to portions of the plains and valleys and most of the area is quite uncultivable. Practically no monsoon rain is received. Bare hills, a general absence of vegetation, except in patches where irrigation is possible, are the characteristic features of a Baluchistán landscape. In some parts, in the direction of Persia, particularly in Chágai, large sandy deserts occur.

The climate varies with the altitude. In the low plains, the conditions resemble those in Sind and in the Punjab, namely, a long, intensely hot summer and a moderate winter. In the higher valleys, where the elevation varies from three to six thousand feet, the year can be divided into four distinct seasons. The winter is very cold with snow and frost and the summer is moderately hot. Great diurnal variations in temperature are a characteristic of the climate. Places of intermediate elevation, such as Chaman and Chágai have an intermediate climate, while the very highest valleys, such as the Toba plateau, are practically deserted in winter, the larger portion of the population migrating to lower altitudes after the crops are sown.

The annual rainfall is everywhere small and varies from 12 inches at Sháhrig to 3 inches in Makrán. Most of the rain falls in connection with the cold weather depressions which pass over the country from the Persian plateau but there are also some minor storms due to the monsoon current. The precipitation is greatest in the highlands and is mostly derived from the winter storms. On the low-lying plains, the rainfall is very small and is mostly received in July and August. The general condition of drought is accentuated by the strong, dry winds which are prevalent in most parts of Baluchistán. These not only dry out the soil very markedly but also, by increasing the transpiration of the plants, increase their consumption of water. The heat of the sun even in the uplands is intense and in some dry farming experiments carried out at Quetta it was found impossible to produce, with ordinary implements, a mulch deep enough to conserve during July and August the moisture of the previous winter rains from the combined effect of sun and wind.

Irrigation.

To ensure a crop, irrigation in some form or other is almost always necessary. A good deal of so-called unirrigated cultivation is carried on but

most of this is really cultivation rendered possible by the water received from the hill torrents. The methods of irrigation employed are very various.

(1) *Rivers and streams.* Owing to the mountainous nature of the country, rivers and hill torrents are numerous. In only a few of the rivers, however, is there any considerable amount of permanent water. Many consist only of a shallow stream, except when flooded by rain from the hills, while in others the bed is quite dry for a large part of the year. Where the ground is soft, as in parts of Kalát, the rivers, on reaching the plain, divide into numerous small streams and are thus immediately available for irrigation. In the rivers with a permanent flow, dams are made of brushwood and earth and the water is led away in open channels. These dams are generally constructed and owned by a hamlet or by a family, who keep them in repair and divide the water thus obtained among the members. Some of these dams are very large. The Mamak dam in the Mula, Kachhi took 700 pairs of bullocks two months to erect. Owing to the flimsy nature of their construction, these dams are continually being breached by the force of sudden floods.

In Makrán, where the rivers often form a series of deep pools, irrigation is carried out by leading the water from these pools on to the fields by open channels. In the case of hill torrents, the fields are embanked and the flood water is led on to them by open channels whenever possible.

(2) *Canals.* These are only to be found in Nasírábád, Sibi, and near Pishin.

(3) *Springs.* Springs are common in the highlands of the Agency, and are much used for irrigation. If the spring is a large one, the water is led directly by open channels on to the land; if it is small, a reservoir is constructed. Water has also been obtained by artesian borings in the Quetta District.

(4) *Kárézes.* The *kárez* is a very ancient form of irrigation peculiar to Baluchistán and Persia. It consists of a series of wells connected by an underground channel. The first well is usually on the talus below the hills and the series is continued until the water debouches on the surface and can be run direct on to the fields. A *kárez* is generally owned by a family or tribal group and the water is shared by time—thus if twelve members own equal shares, each in turn will use the entire flow for twenty-four hours. Repairs are carried out by the headman at the expense of the owners.

(5) *Wells.* Well irrigation is not much practised except in parts of Sibi and parts of Kachhi where the practice is said to be increasing.

Generally speaking, the methods of irrigation practised are extremely wasteful and nothing is more surprising in such an arid region than to see how little care and thought have been expended by the inhabitants in conserving and using to the best advantage the small amount of water available.

The Cultivation of Wheat.

Wheat is the principal crop of the uplands, while in the plains of Sibi and Kalát the *khárif* crops are more important. The crop is grown under irrigation and on rainfall only. Irrigated wheat is generally sown from October to December. Usually the land is watered and the seed sown broadcast, after which, it is ploughed in and covered with the beam. In some cases, the seed is sown in the dry ground and watered afterwards. The number of subsequent waterings varies with the locality but is generally considerable and may be as many as seven. In January and February, the crop is grazed. Harvest extends from May to July, according to the altitude. The grain is trodden out by bullocks, often assisted by a threshing frame. Owing to the prevalence of wind, separation is easy and is generally carried out by a four-pronged wooden fork. The grain heap is sealed with earthen seals until the division can be carried out. The revenue in some Districts is still taken in kind.

Rain-fed wheat is often drilled, both in embanked fields which have been flooded and also in land moistened by rain only. The yield depends on the spring storms. The crop is generally a very small one, never yielding more than 5 or 6 maunds to the acre.

Irrigated wheat is generally heavily manured in the neighbourhood of towns and villages, while rain-fed wheat is always unmanured. Land being so much more plentiful than water, an extensive system of fallowing is practised. Irrigated wheat land is always fallowed for at least a year ; sometimes if the land is very poor for as long as ten years. Rain-crop land, on the other hand, is not fallowed. It is probable that the real effect of the fallow is to aerate the soil, which is very poor in humus and which, after the constant irrigation under a strong sun, bakes into a cement-like mass. In the neighbourhood of Quetta, wheat seldom ripens normally and does not develop the proper amount of colour in the chaff and grain. It withers rather than ripens and the grain is always shrivelled. This is due to the fact that during the ripening period, when the temperature rapidly rises, moisture is quickly lost from the baked surface while air can no longer penetrate to the roots of the plant. Under such circumstances, the wheat dries up rather than matures.

A method of growing wheat with one irrigation, followed by the use of implements for breaking the surface crust, has been worked out at the Quetta Fruit Experiment Station. On unmanured land, a greater yield was obtained from this single preliminary irrigation than by the people on similar land with seven irrigations. A full account of these experiments will be found elsewhere.[1, 2] The adoption of this improved method of production, which is well within the means of the local *zamindar*, would not only increase the yield per acre but would also enable a much larger area to be put under wheat with the amount of water at present available. The wheat produced would moreover be better developed and of higher quality. It is probable that the introduction of an early maturing variety would also prove beneficial.

Grain Quality.

There is a general consensus of opinion that the Baluchistán wheats are not of good quality. They are said to be markedly inferior to those of the Punjab, which are much preferred for food. As none of the Punjab wheats, however, have really good quality or strength[3] it would appear that the Baluchistán wheats are particularly poor. This is due partly to the system of cultivation and partly to the nature of the varieties grown. The grain has all the characteristics of weak wheat.

In order to throw further light on the local ideas regarding the inferiority of these wheats, two samples from Baluchistán were included among a number of Indian samples sent in 1909 to Mr. A. E. Humphries, Past President of the Incorporated National Association of British and Irish Millers, for complete milling and baking tests. One of the samples represented the ordinary red wheat of Quetta and was obtained through Khan Bahadur B. J. Patel, C.I.E., of the St. John's Mills, Quetta. The other was a sample from Mastung obtained through the Political Adviser to the Khan of Kalát. Mastung wheat is supposed to be markedly superior to the other wheats of Baluchistán. The following is the report[4] received from Mr. Humphries. It will be seen that neither sample was of good quality.

" *Baluchistan wheats.* The twenty-nine lots included two, named No. 1 Mastung and Red Quetta, both of which I understand came from Baluchistán.

[1] Annual Report of the Imperial Economic Botanists, Pusa, 1914-15.

[2] Howard and Howard, *Bulletin No. 4 of the Quetta Fruit Experiment Station, 1915.*

[3] One of the most important characteristics of a wheat from the point of view of consumption is its "strength" by which is meant the capacity of the resulting flour to make large, well-shaped loaves. The same grain qualities which produce a good loaf also produce a good *chapati.*

[4] Howard and Howard, *Bulletin No. 22 of the Agr. Res. Institute, Pusa, 1911.*

The former sample contained mostly soft white wheat but it also contains some soft red and some hard red wheat. This lack of uniformity in texture is a bad point, one to which British buyers attach much importance. It behaves very well in the conditioning and milling processes. In the notes on appearance which I dictated as a first stage in these investigations I said 'nothing special at all in this sample. Should be surprised if it yields strong flour.' Nor does it. It is Indian wheat of an ordinary undistinguished type.

The red Quetta contains a large proportion of white wheat similar to the Mastung. The berries are irregular in shape and comprise some very hard, and some soft by nature. This kind does not appear to be strong and it is not so. The description I have used concerning Mastung applies to red Quetta also. The baker's note concerning the flavour of the bread from these two kinds is 'Very dry, very chaffy. Tastes like flour itself.' The last remark, if inaccurate, is expressive. No wonder the natives prefer durums to such varieties for their own food."

That there is nothing inimical to the production of strong wheats in the climate or soil of Baluchistán has been shown by the behaviour of some of the improved Pusa wheats at Quetta. Pusa 4, Pusa 6 and Pusa 12, all wheats with good quality, have been grown at the Fruit Experiment Station during the last few years. The samples obtained show that these strong wheats do not deteriorate in quality under the new conditions.

Unfortunately few of the Indian wheats are suitable for distribution in Baluchistán on account of the nature of their root development. The root system which suits the plains of India is not well adapted to withstand the drought and cold of Baluchistán, which necessitate a much deeper and stronger rooting power. In 1910, however, some crosses were made between Pusa wheats of good quality and some high-yielding English kinds.[1] Many of the progeny have very strong rooting power and it is possible that some of the new wheats derived from these crosses will be found suitable. For the Quetta valley, an early maturing variety with good quality would be a great benefit particularly as the new system of cultivation if adopted would lead to a better development and ripening of the grain.

Classification.

As regards the systematic aspect of the subject, the method employed in former publications,[2, 3] for the classification of the wheats of India has

[1] Annual Report of the Imperial Economic Botanist, 1913.

[2] Howard and Howard, *Memoirs of the Department of Agr. in India* (*Bot. Ser.*) vol. 2, no. 7, 1909.

[3] Howard and Howard, *Wheat in India*, Calcutta, 1910.

been adopted. This scheme was based on the sub-division of *Triticum sativum* Lam. into six sub-species and on the botanical varieties proposed by Koernicke.[1]

Triticum sativum Lam. Ears with a fertile terminal spikelet and brittle or tough rachis. Outer glumes shorter than the flowering glumes, with or without a blunt tooth at the side. Pales as long as the flowering glumes, undivided.

I. Rachis brittle. Grain enclosed in the glumes when threshed.

1. *Triticum spelta* L. Spelt. Ears bearded or beardless, long and thin, lax and somewhat square. Outer glumes very broad and truncated with a very short and blunt apex and a somewhat undeveloped keel.

2. *Triticum dicoccum* Schrk. Emmer. Ears nearly always bearded, dense, broader on the two-rowed side, outer glumes sharply keeled with an acute apex.

II. Rachis tough. Grains separating from the chaff when threshed.

3. *Triticum compactum* Host. Dwarf wheats. Ears bearded or beardless, extremely short and very compact, more or less quadrangular. Outer glumes keeled above, rounded below. Straw very short and stiff. Grains rounded.

4. *Triticum turgidum* L. Rivet wheats. Ears bearded, large and four-sided with the spikelets closely packed on the rachis. Straw very tall, stiff, often solid. Grains large, short, and plump with a blunt apex.

5. *Triticum durum* Desf. Macaroni wheats. Ears large, dense with long awns. Outer glumes sharply keeled to the base. Straw stiff, usually solid. Grains long, somewhat pointed and hard.

6. *Triticum vulgare* Vill. Common wheats. Ears bearded or beardless, more or less lax (much laxer than *T. compactum*). Outer

[1] Koernicke, *Die Arten und Varietäten des Getreides*, Berlin, 1885.

glumes keeled above, rounded below. Straw hollow, medium in length. Grains not rounded, more than twice as long as broad.

It must be admitted that the distinctions between the sub-species are not always very clear and that intermediate forms can be found combining characters from two sub-species. Koernicke pointed out that brittleness of the rachis, persistence of the glumes round the grain and the peculiar glume-shape is not always well defined in all the forms of *T. spelta*. On the other hand, the glume-shape of *T. spelta* is sometimes to be found in forms belonging to *T. vulgare* and *T. compactum*. He also emphasized the difficulty of distinguishing between *T. durum* and *T. turgidum*. This difficulty was encountered in the present survey. *Orbasin* wheat from Fort Sandeman (Baluchistán Class VIII) could with almost equal justice be assigned to either of these two sub-species. As Koernicke[1] points out, the ultimate decision must in such cases always be a subjective one depending on the emphasis laid by the individual observer on any particular character. In the case of *T. compactum* and *T. vulgare*, the distinctions based on the glume and grain shape break down utterly. In the Himalayan tracts, a large number of wheats are found which combine the ear-shape and the general characters of *T. vulgare* with glumes and grain as rounded as in a typical *compactum*. It is often possible to find in the same sample two wheats identical in every respect except that one has rounded glumes and rounded grain and in the other the glume-shape typical of *T. vulgare* with long grain.

This has been pointed out in a previous publictaion[2] but was found to be ven more striking in the case of many of the Baluchistán wheats. It is a urious fact that wheats of this type are not to be found in the plains of India lthough some of the Bengal wheats approximate to this condition. Such heats have been found in the Himalayas near Simla, in Baluchistán and also Khorásán. The yield of these wheats must necessarily be small as they are ways very lax and the grain is of small size. The short glume of a *T. compactum* combined with the rachis of an ear of *T. vulgare* leads to the production of a structure inefficient in the extreme from the point of view of yield. is possible therefore that those forms represent the survival of an old type wheat which has been replaced in the plains of India by higher yielding rms of *T. vulgare*. On the other hand, they bear a close resemblance to the ogeny obtained by crossing *T. compactum* and *T. vulgare* and the regions

[1] Koernicke, l.c.

[2] Howard and Howard, *Wheat in India*, l.c.

in which they occur are regions of great aridity in which natural crossing is common. It is possible therefore that they represent the result of such crossing. As, however, at the present time, no dwarf wheats are found in any of the localities mentioned, this would appear to be improbable.[1]

In the conception of the variety, the definition of Koernicke[2] has been followed. A variety is considered to be a group of forms distinguishable from other forms by some definite botanical or morphological character which can be easily recognized in any well-grown individual and conversely, the individual forms comprised in the group should be indistinguishable among each other by any such character. Botanical or morphological characters may be defined as those which remain constant with change of environment or season and which can be determined in the laboratory from properly developed specimens.

In contradistinction to botanical characters are agricultural or field characters which cannot be distinguished in the laboratory or from individual plants but can only be fully appreciated in the field in pure cultures, grown side by side, under uniform conditions. Such characters are time of maturity, height, susceptibility to rust.

As the classification of the wheats in this paper is of necessity based on ripe specimens, the only characters which could be employed were botanical or morphological ones and the classification therefore does not go beyond the botanical variety.

The characters employed by Koernicke in grouping his system of botanical varieties were the following in the order given :—

(*a*) Ears bearded or beardless.
(*b*) Felted or smooth chaff.
(*c*) Colour of the chaff (red, white, or black).
(*d*) Colour of the grain (red or white).

An examination of a much larger number of forms than those which were at the disposal of this observer and also the results of modern investigations on the inheritance of characters in wheat have shown that the alternatives enumerated above by no means cover the number of characters available for the distinction of botanical varieties. To take the first case, "ears bearded or beardless," it has been recently pointed out that the degree of bearding.

[1] Since the above was written, wheats of the type described have been obtained in the F_2 of a cross between a macaroni and an ordinary wheat.

[2] Koernicke, l. c.

hat is the length and arrangement of the awns, on a wheat, may vary in several rays.[1] An entirely beardless wheat is rare. In India, particularly, a large umber of wheats are neither fully bearded nor entirely beardless, but possess hort awns of varying length. These awns may be so short as to form small ips to the glumes or the wheats may appear to be half-bearded. The long wns on a fully bearded ear are due to two factors, each of which when present lone, produces a half-bearded ear which breeds true to this character. Various ypes of bearding are shown in Plate I. It is evident that any system in which nly two alternatives, bearded and beardless ears, are considered is incomlete and will result in the grouping together of a large number of very different orms. In the same way it has been shown that the felting in some wheats due to the presence of two kinds of hairs, while in others only one kind is resent. The difference is easily recognizable macroscopically on single ears y the density of the felting.

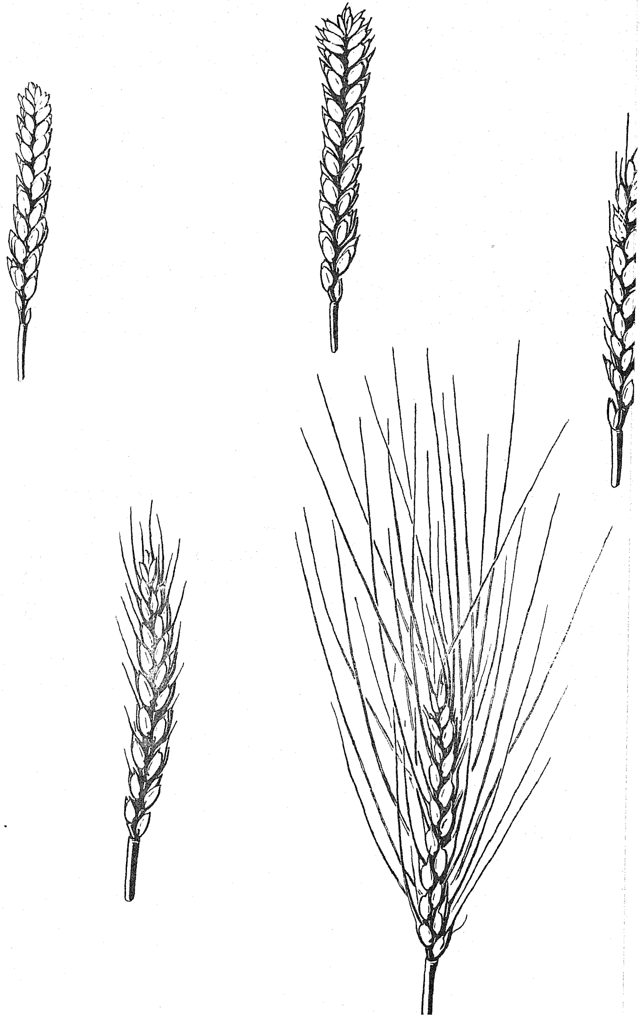
Although it has also been demonstrated that the red colour of the chaff nd grain is not uniform in all wheats, but varies in tone owing to the presence r absence of several factors for red colour,[2,3] nevertheless this is not of reat significance in a botanical classification, as it is impossible to distinguish ccurately such differences except by breeding. It is sometimes possible to istinguish two wheats by the tone of colour of their chaff but such distincons can only be seen in the bulk and must remain of very minor importance. hey can have no place in the main divisions of a classificatory scheme.

Two other characters which are not considered in the above scheme can, owever, be very usefully employed in addition and these are glume-shape nd grain-shape. As pointed out above, the distinctions between the subecies based on glume-shape break down to some extent. Wheats belonging *T. vulgare* may be found with distinctly rounded glumes. This is an easy naracter to determine in dried specimens and is therefore very suitable for se in a botanical classification. Grain-shape is also a character which can be nployed as a means of distinguishing one wheat from another. Examinaon of the progeny of a large number of crosses shows that this character definitely inherited and is not materially influenced by changes in environent. A certain amount of practice is required before the eye can distinuish the different forms of grain but any one accustomed to handle wheat

[1] Howard and Howard, *Memoirs of the Dept. of Agr. in India (Bot. Ser.)*, vol. III, no. 6, 13, and vol. V, no. 1, 1915.

[2] Nilsson Ehle, *Kreuzungsuntersuchungen an Hafer und Weizen*, Lund, 1909.

[3] Howard and Howard, *Mem. of the Dept. of Agr. in India (Bot. Ser.)*, vol. III, no. 6, 13.



can make out the components of a mixed sample with tolerable accuracy. There are four shapes which are most frequently found and which have been employed as an aid to classification in the present paper; the ordinary long grain, which is the best known form, the short or truncated form, *i.e.*, one in which the end appears to have been cut off, the rounded form, and the form in which the dorsal side is raised. This latter bears some resemblance to the hump of a camel and as a word was required to describe it shortly, the term "humped" has been employed. All four forms are shown very much enlarged in Figure 1.

Another character which is useful is the colour of the straw. Many Indian wheats exhibit a pink tinge on the straw on ripening. The pink colouring matter turns black when the straw is quite ripe and gives the latter a grey or purple appearance. This peculiar colour of the straw is easily seen and is a definitely inherited character.

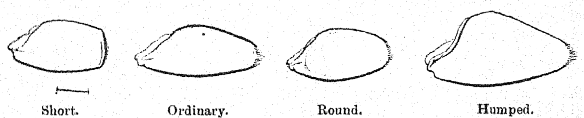


Fig. 1.—Grain-shape in wheat.

Enough has been said to show that modern investigations have rendered the scheme of botanical varieties proposed by Koernicke somewhat out-of-date. There are three principal reasons why the scheme is no longer adequate. In the first place, the characters chosen do not present simple alternatives such as presence or absence of awns but may be present to different degrees. In the second place, the characters employed are too few and, as a result, many wheats, obviously different even on a macroscopic examination in the laboratory, fall into one variety. Thirdly, as material from other parts of the world has become available, new forms have been found necessitating new varietal names. For instance, there is no varietal name for a bearded wheat with black awns, red and black chaff and white grain although such wheats occur in Bihar. The need for a revised systematic scheme for wheat is obvious, but such a scheme must be based on examination of wheats from all parts of the world and to devise a new scheme for the Indian wheats by themselves would only add to the confusion and would prove of no ultimate advantage.

In the present paper, the botanical varieties, as defined by Koernicke, have been subdivided where necessary into classes, the class distinctions being based on the degree of bearding, felting, the tone of colour of the chaff, glume-shape, shape of the grain and colour of the straw.

As regards the terms bearded and beardless, all wheats in which the ns are half an inch or more long have been classed among the bearded rieties, but in the descriptions the term bearded has been qualified by such m as fully bearded and half-bearded. As the samples had to be sent g distances and were collected and despatched by subordinate officials h little or no knowledge of the care necessary in sending specimens, it is surprising that a good deal of breakage took place, especially of the as. This has made it difficult, in some cases, to determine the degree of rding, and it is possible that this may not always have been quite urately described.

There is a curious want of colour about the wheats both from Baluchistán Khorásán. The red colour of the chaff and of the grain, if present, is and poorly developed. In the plains, white-chaffed or white-grained ats are really yellow in colour and it is only a convention to term them te, but in these arid regions they approximate more to a true white and e a dead or dull appearance. It is probable that this want of development of the red and the yellow colouring matter is due to the conditions under h the wheat ripens. As pointed out above, constant irrigation under a sun and wind, by producing a cement-like condition of the soil imper-ble to air, induces withering rather than ripening.

The most striking point about the Baluchistán wheats is the large ber of different kinds cultivated. Two varieties of rivet wheats which d be subdivided into three classes, four varieties of macaroni wheats falling six classes, one variety of *compactum* and eighteen varieties of *T. vulgare* prising fifty-four classes were found. Considering how small the actual under cultivation is, this was somewhat unexpected. Baluchistán is the part of India in which rivet wheats occur.

II. CLASSIFICATION AND DESCRIPTION OF THE TYPES.

. CLASSIFICATION OF THE WHEATS OF BALUCHISTÁN.

TRITICUM TURGIDUM L. RIVET WHEATS.

. Glumes felted.

A. Glumes white, awns black.

a. Grain white.

var. *Salomonis* Kcke.

Baluchistán Class I.

2. Glumes smooth.

A. Glumes white.

a. Grain white.

var. *nemausense* Wittm.

Baluchistán Class II. Ears short, much broader at the base than at the top ; awns black.

Baluchistán Class III. Ears long, not markedly broader at the base ; awns white ; glumes with a white bloom.

TRITICUM DURUM DESF. MACARONI WHEATS.

1. Glumes felted.

A. Glumes white, awns black.

a. Grain white.

var. *melanopus* Al.

Baluchistán Class IV. Ears very lax and slender ; glumes very long with well-marked lateral ridges ; grain exceptionally long even for a macaroni wheat.

Baluchistán Class V. Ears long, less lax and thin than in Class IV ; lateral ridges not prominent ; no black colour on glumes ; grain very long.

Baluchistán Class VI. Ears short and dense ; a good deal of black on the glumes ; grain somewhat short.

2. Glumes smooth.

A. Glumes red, awns red.

a. Grain red.

var. *murciense* Kcke.

Baluchistán Class VII.

b. Grain white.

var. *hordeiforme* Host.

Baluchistán Class VIII.

B. Glumes white, awns black.

a. Grain white.

var. *leucomelan* Al.

Baluchistán Class IX.

TRITICUM COMPACTUM HOST. DWARF WHEATS.

Ears beardless.

1. Glumes smooth.
   - A. Glumes white.
     - *a.* Grain white.

var. *Humboldti* Kcke.

Baluchistán Class X.

TRITICUM VULGARE VILL. COMMON WHEATS.

Ears bearded.

1. Glumes felted.
   - A. Glumes red.
     - *a.* Grain red.

var. *barbarossa* Al.

Baluchistán Class XI. Ears quadratic in section, dense; awns black.

Baluchistán Class XII. Ears medium to lax; awns black; glumes somewhat short and rounded with some black colouring; grain small and rounded.

Baluchistán Class XIII. Ears long and lax; awns and chaff reddish brown; grain rather large; straw strong.

Baluchistán Class XIV. Ears short, somewhat dense; chaff red with a bluish bloom; grain short, somewhat rounded; straw thin to medium.

b. Grain white.

var. *turcicum* Kcke.

Baluchistán Class XV. Ears long and lax; chaff reddish brown, hairs long and dense.

Baluchistán Class XVI. Ears long, laxer than in Class XV; chaff pale red with a bluish bloom.

Baluchistán Class XVII. Ears short and somewhat lax; glumes short and rounded; grain short and round.

B. Glumes greyish white with some black; awns black.

var. *fuliginosum* Al.

Baluchistán Class XVIII. Ears long, lax, bold; awns short and spreading; grain large, humped, pale red; straw very stout and strong.

Baluchistán Class XIX. Ears long, lax, not bold; awns not spreading; grain neither humped nor rounded, somewhat dark red; straw medium.

Baluchistán Class XX. Ears short, medium to dense; awns not spreading; grain small, rounded, pale red; straw medium.

C. Glumes white, awns white.

a. Grain red.

var. *Hostianum* Clem.

Baluchistán Class XXI. Ears medium in length, fully bearded, awns long; grain somewhat large, red.

Baluchistán Class XXII. Ears medium to long, fully bearded, awns short; grain dark red, long.

Baluchistán Class XXIII. Ears short and thin, fully bearded; glumes rounded, short, very white; grain short, round, pale red.

Baluchistán Class XXIV. Ears partly bearded; glumes short and rounded; grain small, humped; straw thin.

Baluchistán Class XXV. Very similar to Class XXIV but ears bolder and larger; grain larger; straw stout and strong.

b. Grain white.

var. *meridionale* Kcke.

Baluchistán Class XXVI. Ears fully bearded; glumes not rounded; grain long, not humped.

Baluchistán Class XXVII. Ears fully bearded; glumes not rounded; grain short, not humped.

Baluchistán Class XXVIII. Ears partly bearded; glumes rounded; grain very humped and short. These might possibly be considered as beardless.

Baluchistán Class XXIX. Ears with long tips or short beards; glumes rounded; grain white, short, very humped; straw strong.

Baluchistán Class XXX. Ears with long tips which are often black; glumes rounded; grain not humped; straw weak.

2. Glumes smooth.

A. Glumes red, awns black.

a. Grain red.

var. *caesium* Al.

Baluchistán Class XXXI.

B. Glumes red, awns red.

a. Grain red.

var. *ferrugineum* Al.

Baluchistán Class XXXII. Ears large and bold, fully bearded; chaff brownish red; grain pale red, large.

Baluchistán Class XXXIII. Ears thin, fully bearded; chaff pale red with bluish bloom; grain smaller than in Class XXXII and of a lighter red.

Baluchistán Class XXXIV. Ears thin, partly bearded; glumes slightly rounded; chaff reddish brown; grain dark red.

Baluchistán Class XXXV. Ears short and thin, slightly bearded; glumes rounded; chaff reddish brown; grain pale red.

b. Grain white.

var. *erythroleucon* Kcke.

Baluchistán Class XXXVI. Ears fully bearded; chaff brownish red with a bluish bloom; grain long not humped.

Baluchistán Class XXXVII. Ears fully bearded; glumes slightly rounded; chaff pale red with bluish bloom; grain with a distinct hump.

Baluchistán Class XXXVIII. Ears fully bearded; chaff brownish red with no bluish bloom; grain somewhat humped.

Baluchistán Class XXXIX. Ears partly bearded, lax; glumes somewhat rounded; chaff with bluish bloom; grain without a hump.

C. Glumes white, awns white.

a. Grain red.

var. *erythrospermum* Kcke.

Baluchistán Class XL. Ears bold, large, fully bearded ; awns stiff and spreading ; grain dark red, large, short, humped ; straw very strong.

Baluchistán Class XLI. Ears lax, not bold, fully bearded ; awns not spreading ; grain dark red, humped ; straw medium, no pink colour.

Baluchistán Class XLII. Ears medium and slender, fully bearded, awns long not spreading ; both awns and glumes with a pink tinge, grain short, not humped, medium sized, light red ; straw weak, pink.

Baluchistán Class XLIII. Ears medium ; chaff with a reddish tinge ; grain on the whole not humped.

Baluchistán Class XLIV. Ears long, lax and slender ; chaff quite white ; grain humped.

b. Grain white.

var. *graecum* Kcke.

Baluchistán Class XLV.

II. Beardless.

1. Glumes felted.

A. Glumes red.

a. Grain red.

var. *pyrothrix* Al.

Baluchistán Class XLVI. Ears medium to long ; beardless with very short tips ; chaff reddish brown.

Baluchistán Class XLVII. Ears short, quite beardless ; chaff red with a certain amount of bluish bloom ; straw pink turning black on ripening.

b. Grain white.

var. *Delfii* Kcke.

Baluchistán Class XLVIII. Ears long and medium in density ; chaff red with bluish bloom.

Baluchistán Class XLIX. Ears short and dense with a fan-shaped apex; chaff reddish brown.

B. Glumes white.

a. Grain red.

var. *velutinum* Schübl.

Baluchistán Class L. Ears with many short tips; chaff yellowish white; grain rounded; straw not pink.

Baluchistán Class LI. Ears quite beardless; chaff yellowish white; grain not rounded; straw not pink.

Baluchistán Class LII. Ears quite beardless or with one or two short tips; chaff very white; straw pink.

b. Grain white.

var. *leucospermum* Keke.

Baluchistán Class LIII. Ears bold and large, dense with fan-shaped apices, flattened; grain short and small; straw extremely strong, pink turning black on ripening.

Baluchistán Class LIV. Ears medium, not flattened; grain short and small; straw fairly strong, pink turning black on ripening.

Baluchistán Class LV. Ears with well-marked tiny tips; glumes somewhat sharply keeled; grain longer than in Classes LIII and LIV; straw thin not pink.

2. Glumes smooth.

A. Glumes red.

a. Grain red.

var. *milturum* Al.

Baluchistán Class LVI. Ears not flattened, tapering at the top; grain pale red.

Baluchistán Class LVII. Ears flattened, broader at apex; grain light red.

b. Grain white.

var. *alborubrum* Keke.

Baluchistán Class LVIII. Ears long, medium; grain round not humped.

Baluchistán Class LIX. Ears short, dense with fan-shaped apices; grain very small, round not humped.

Baluchistán Class LX. Ears lax; glumes rounded; grain humped.

B. Glumes white.

a. Grain red.

var. *lutescens* Al.

Baluchistán Class LXI.

b. Grain white.

var. *albidum* Al.

Baluchistán Class LXII. Ears tapering at the top, medium to lax; straw thin; grain not rounded.

Baluchistán Class LXIII. Ears dense, very bold, with fan-shaped apices; grain very small, round; straw very strong.

Baluchistán Class LXIV. Ears dense, small, with fan-shaped apices; grain medium sized, not rounded; straw weak.

B. DESCRIPTION OF THE WHEATS OF BALUCHISTÁN

TRITICUM TURGIDUM L. RIVET WHEATS.

Ears square and dense, bearded; glumes sharply keeled to the base; straw stout, stiff and solid; grain plump, short, rounded, very large.

var. *Salomonis* Kcke.

Baluchistán Class I. Ears short, broader at the base than at the top; awns black; glumes felted, white; grain white, soft.

Wheats belonging to this class were found in *Pindaro* wheat from Panjgúr, Makrán and in *Pashmak* wheat from Khárán, Kalát.

var. *nemausense* Wittm.

Baluchistán Class II. Ears short, broader at the base than at the top; awns black; chaff white, smooth; grain white, soft.

Pashmak wheat from Chágai belongs to this class. This wheat is only cultivated in the Kallagh settlement of the Ráskoh Range and occurs nowhere else in the District. It is used almost exclusively to make porridge as the flour does not bind well enough for *chapatties*. It requires a good supply of irrigation water. The same wheat also formed part of the sample of *Pashmak* wheat from Khárán, Kalát.

Baluchistán Class III. Ears very long, apex and base about the same ·eadth, awns white ; chaff smooth, white with a white bloom ; grain white, ft.

Wheat belonging to this class was found in *Spín ghanam* from Sháhrig, bi.

TRITICUM DURUM DESF. MACARONI WHEATS.

Ears flat, flowering glumes with long awns ; outer glumes sharply keeled the base ; straw stiff and solid ; grains long.

var. *melanopus* Al.

Baluchistán Class IV. Ears very lax and slender ; awns long and black ; umes exceedingly long with well-marked lateral ridges, somewhat sparsely lted except on the ridges, white ; grains exceptionally long even for macani wheats and much compressed laterally, white.

A specimen of this wheat termed *Mecca Muazzama ghanam*, Mecca wheat, ts received from the Kila Saifulla tahsíl of the Upper Zhob Sub-division. the name implies, this variety is supposed to have been imported from ecca in very small quantity by *hajis*. It is considered so sacred that it cannot sown without performing the ceremony of ablution which is necessary for e offering of prayers. Any increase in the cultivation of this variety is ndered by the great respect in which the grain is held by Mohammadan riculturists. Its chief use appears to be to neutralize the effect of the evil e in a field. A single ear identical with the above was found in a specimen *Wadának* wheat sent from Duki.

The wheat known as *Siah das* in Khorásán is probably identical with s.

Baluchistán Class V. Ears long, medium, less lax and thin than in ıss IV ; awns long and black ; glumes long, lateral ridges not prominent, ted, white with no blackening ; grain white, hard, exceptionally long even a macaroni wheat ; straw pink.

To this class belongs a wheat from Duki known as "*Wadának* of the njab." It is an introduced wheat and is only cultivated on a very small scale ı few places. It is probably identical with Type I of the Punjab wheats.[1]

Baluchistan Class VI. Ears short and dense ; awns black (an intense ning black) ; glumes with a good deal of blackening ; grain dark amber 'd, somewhat short for a macaroni.

[1] Howard and Howard, *Wheat in India*, p. 177.

To this class belongs *Tor ghanam* from Fort Sandeman, Lower Zhob, the name having reference to the black glumes. A few ears of the same wheat were found in a sample of *Pindaro* wheat from Panjgúr, Makrán.

Malão ghozhiza wheat from Músa Khél, Loralai belongs either to Class V or Class VI. It is only grown on irrigated land but is said to be in general cultivation.

var. *murciense* Kcke.

Baluchistán Class VII. Ears medium in length and medium in density; awns light red; chaff smooth, light red; grain red.

Wheats belonging to this class were only found in small quantities in a sample of *Pindaro* wheat from Panjgúr, Makrán and in a sample of *Sra ghanam* from Fort Sandeman, Lower Zhob.

var. *hordeiforme* Host.

Baluchistán Class VIII. Ears very short and dense; awns light red; chaff smooth, light red; grain rather short and humped, soft, white.

The wheats belonging to this class bear some resemblance to rivet wheats. The grain is shorter and more humped than is generally the case with macaroni wheats, and some difficulty was experienced in correctly classifying them. On the whole, however, they appear to have more in common with the sub-species T. *durum*.

Orbasín ghanam from Fort Sandeman, Lower Zhob belongs to this class. A very small quantity of the same wheat was also found as an impurity in *Tor ghanam* from the same locality.

var. *leucomelan* Al.

Baluchistán Class IX. Ears medium in length, dense; awns with some blackness; chaff smooth, white with a reddish edge; grain not humped, soft, long, white.

About half the sample of *Pindaro* wheat from Panjgúr, Makrán, consisted of a wheat belonging to this class.

TRITICUM COMPACTUM HOST. DWARF WHEATS.

Ears very dense and short, rarely over two inches long; outer glumes keeled in the upper half and rounded in the lower half; straw very short and stiff; grains rounded.

var. *Humboldti* Keke.

Baluchistán Class X. Ears very short, beardless ; glumes smooth, white ; rain small, round, white, hard.

Wheats belonging to this species are not cultivated in Baluchistán although ey are fairly common in the adjacent Province of the Punjab. Only a very nall quantity of a wheat belonging to this class was found as an impurity two samples of wheat *Thori* and *Wáru*, both from Gandáva, Kachhi, Kalát.

TRITICUM VULGARE VILL. COMMON WHEATS.

Ears bearded or beardless ; outer glumes not keeled to the base ; straw ollow ; grain neither very long nor round.

var. *barbarossa* Al.

Baluchistán Class XI. Ears quadratic in section, dense and somewhat ort, bearded ; awns black ; chaff densely felted with long hairs, pale red ; ain red.

Only one wheat belonging to this class was found in *Mátoshag* from Kéch, ıkrán.

Baluchistán Class XII. Ears bearded ; glumes somewhat short and unded, felted, reddish brown with some black ; grain red, small and unded.

Wheat belonging to this class was only found as an impurity in very all quantity.

Baluchistán Class XIII. Ears long, bearded ; awns reddish brown ; ıff felted, reddish brown ; grain pale red, rather large ; straw strong.

Vheats belonging to this class were also found in small quantity only impurities in *Spín ghanam* from Sanjáwi, Loralai ; in *Spín ghanam* from i, Loralai ; in *Spín ghanam* from Kila Saifulla, Upper Zhob ; in a sample *Bati razi* from some district unknown and in a sample from Mach.

Baluchistán Class XIV. Ears short, somewhat dense, bearded ; awns t and light red ; glumes red with a bluish bloom ; straw thin to medium ; n short, red, somewhat rounded.

This was found in very small quantity as an impurity in a sample of at from Mach and in *Thori* wheat from Nasírábád, Sibi.

var. *turcicum* Kcke.

Baluchistán Class XV. Ears long and lax, bearded ; awns red ; glumes densely felted with long hairs, reddish brown ; grain white, soft ; straw fairly strong.

To this class belong *Spín ghanam* from Bori, Loralai, and *Spín ghanam* from Kila Saifulla, Upper Zhob. Similar wheats occurred in *Sára ghanam* from Duki, Loralai ; in *Spín ghanam* from Sanjáwi, Loralai ; in *Kajani* or *Borji* wheats from Sibi *tahsíl*, Sibi ; in *Soor ghanam* from Sháhrig, Sibi ; and in *Turki* wheat from Dálbandin, Chágai.

Baluchistán Class XVI. Ears longer and laxer than in Class XV, bearded ; glumes felted but hairs are less dense and shorter than in the previous class ; grain white, soft ; straw stronger than in Class XV.

Wheat belonging to this class was found in very small quantity only as an admixture in *Bujri* from Nasírábád, Sibi.

Baluchistán Class XVII. Ears short, lax, bearded ; glumes short and rounded ; densely felted as in Class XV, reddish brown ; grain short, rounded, white, soft.

This was only found as an admixture in small quantity in two samples from Mach.

var. *fuliginosum* Al.

Baluchistán Class XVIII. Ears long, lax, bearded, with short, spreading, black awns ; glumes somewhat rounded, felted, white ; grain large, humped, somewhat like rivet grain, red, soft ; straw very stout and strong.

This wheat was found as an admixture in *Kamar ghanam* from Chaman, Quetta-Pishín ; in *Spín ghanam* from Kákar Khorásán, Lower Zhob, and in *Sara ghanam* from Bori, Loralai.

Baluchistán Class XIX. Ears long and lax, less bold than in Class XVIII ; awns black but not spreading ; glumes felted, greyish white ; grain neither humped nor rounded, somewhat dark red ; straw medium.

Wheats belonging to this class occurred in *Wáru* from Dhádar, Kachhi Kalát, in *Siah das* from Dálbandin, Chágai ; in *Pámbarin* and *Toda* wheats from Quetta and in two samples from Mach.

Baluchistán Class XX. Ears short, medium to dense, bearded ; awns long, black, not spreading ; glumes felted, greyish white ; grain pale red, short, rounded soft ; straw medium.

Wheats belonging to this class occurred in small quantity as admixtures in *Bujri* and *Thori* wheats from Nasírábád, Sibi; in *Thori* wheat from Gandáva, Kachhi, Kalát; in *Urbsen* wheat from Músa Khél, Loralai; in *Sára ghanam* and *Laghar* from Bori, Loralai and in *Tor ghanam* and *Sra ghanam* from Fort Sandeman, Lower Zhob.

This variety *fuliginosum* occurs only as an admixture and nowhere forms the bulk of the wheat cultivated. Punjab Type 9, a very distinctive wheat of the Punjab known as the *Ratti* of Montgomery belongs to this variety and it is probable that some has found its way into Baluchistán.

var. *Hostianum* Clem.

Baluchistán Class XXI. Ears medium in length, and density; awns ong and white; glumes felted, white; straw strong; grain somewhat large, ed, shape ordinary.

Wheats belonging to this class were found as admixtures in *Dahak* wheat rom Panjgúr, Makrán; in *Bujri* wheat from Nasírábád, Sibi; in *Kali ghanam* rom Chaman, Quetta-Pishín; in *Lakhi* wheat from Bárkhán, Loralai; in *izha* wheat from Músa Khél, Loralai,; in *Toda* wheat from Quetta, in *Dahyak* from Nushki, Chágai and in *Turki* wheat from Dálbandin, Chágai.

Baluchistán Class XXII. Ears medium to long, medium in density; wns short; glumes felted, white; grain dark red, long, hard.

Wheats belonging to this class occurred as admixtures in *Shahderzi* wheat, *Bati razi* wheat and in five samples from Mach.

Baluchistán Class XXIII. Ears short and thin; medium to lax; awns hite; glumes short and rounded, felted, white; grain pale red, short, und; straw weak.

Wheats belonging to this class were found as admixtures in *Kamar*, *Sàra* d *Spín* wheats from Pishín; in *Pambarin* and *Spín* wheats from Quetta; *Godewoda* wheat from Chaman, Quetta-Pishín and in three samples from ach.

Baluchistán Class XXIV. Ears medium in length, lax, partly bearded *e.*, beards not so long as in fully bearded wheats); glumes short and ted, white; grain small, short, red, soft, distinctly humped in shape; straw n.

Wheats belonging to this class were found as admixtures in *Ghat ghanam* m Fort Sandeman, Lower Zhob, in *Saloman razi*, *Khuda daderzi*, *Kumar*

and *Shahderzi* wheats, in a sample of white wheat from Nushki, Chágai in *Turki* wheat from Dálbandin, Chágai; in *Sra ghanam* from Kila Saifulla, Upper Zhob and in a sample from Mach.

Baluchistán Class XXV. This is very similar to the last class but the heads are larger and bolder, the grain is larger and the straw strong and stout.

This was only found as an admixture in one sample of *Kumar* wheat from Chaman, Quetta-Pishín.

var. *meridionale* Kcke.

Baluchistán Class XXVI. Ears fully bearded, medium in density; glumes felted, white; grain white, somewhat long, shape normal.

Kamar ghanam from Chaman, Quetta-Pishín, belongs to this class and also another sample from some place unknown labelled *Kumar*. Wheats belonging to this class also occurred as impurities in *Toda* wheat from Quetta; in *Bujri* and *Thori* wheats from Nasírábád, Sibi; in *Spín ghanam* from Chaman, Quetta-Pishín; in *Spín ghanam* from Kákar Khorásán, Lower Zhob; in *Sra ghanam* from Hindubágh, Upper Zhob; in *Sára ghanam* from Bori and *Sanjáwi*, Loralai; in five samples named *Khuda dadarzi*, *Madar khushkába*, *Shahderzi*, *Bati razi* and *Saloman razi;* and in *Turki* wheat from Dálbandin, Chágai.

Baluchistán, Class XXVII. This class is very similar to the above but differs in glume and grain shape, the latter being smaller and shorter.

Wheats belonging to this class occurred as admixtures in a sample from Quetta, in *Kamar* and *Spín* wheat from Pishín and in four samples from Mach.

Baluchistán Class XXVIII. Ears not quite fully bearded, medium to lax in density, medium in length; glumes rounded, felted, white; grain white, short and very humped in shape; straw strong and pink.

To this class belong *Pambarin* from Quetta; a sample named *Madar khushkába*; *Spín* wheat from Pishín; and two unnamed samples from Quetta; *Spín* wheat from Hindubágh, Upper Zhob; *Spín ghanam* and *Kali ghanam* from Chaman, Quetta-Pishín and four samples from Mach. Wheats belonging to this class were also found as admixtures in *Kamar ghanam* and *Godewoda* wheat from Chaman, Quetta-Pishín and in *Kamar* wheat from Pishín.

Baluchistán Class XXIX. Ears with very short, white awns; glumes rounded, felted, white; grain white, in shape very much humped; straw strong.

To this class belong *Turki* wheat and an unnamed sample from Nushki, Chágai ; *Turki* wheat from Dálbandin, Chágai and five samples named *Salomon razi, Bati razi, Shahderzi, Khuda dadarzi,* and *Kamar ; Spín* wheat from Hindubágh, Upper Zhob ; and *Spín ghanam* from Sháhrig, Sibi.

Baluchistán Class XXX. Ears with small tips, often black ; glumes felted, white, rounded ; grain white, normal in shape.

To this class belong *Ghat ghanam* from Fort Sandeman, Lower Zhob ; *Spín koshám* from Kila Saifulla, Upper Zhob ; *Laghar* wheat from Bori, Loralai ; and similar wheats occurred as admixtures in *Sára ghanam* from Bori, Loralai ; in *Sra ghanam* from Fort Sandeman, Lower Zhob, and in a sample from Mach.

It is difficult to say whether these two Classes XXIX and XXX should be assigned to var. *meridionale* Kcke. or to var. *leucospermum* Kcke., that is whether the wheats should be considered bearded or beardless.

var. *caesium* Al.

Baluchistán Class XXXI. Ears small with small glumes, somewhat lax, fully bearded ; awns black ; glumes smooth, red with a good deal of black; grain red, small ; straw somewhat weak. All the specimens received were immature which would point to this being a late kind.

To this class belong *Chirok* from Kéch, Makrán ; and *Siah das* from Dálbandin, Chágai. A similar wheat also occurred in *Dahyak* from Nushki, Chágai.

var. *ferrugineum* Al.

Baluchistán Class XXXII. Ears large, medium in length, bold, lax, fully bearded ; glumes brownish red, shiny ; grain pale red, large, plump ; straw weak to moderately strong.

To this class belong *Sára ghanam* from Duki, Loralai and similar wheats occurred as admixtures in *Spín ghanam* from Sanjáwi, Loralai ; *Spín ghanam* from Kila Saifulla, Upper Zhob ; *Kahani* or *Bujri* wheat from Sibi ; *Wáru* wheat from Dhádar, Kachhi, Kalát ; *Rodi* and *Lákhi* wheat from Bárkhán, Loralai ; *Bujri* from Nasírábád, Sibi ; in a sample from Kohlu, Sibi ; in *Soor ghanam* from Sháhrig, Sibi ; *Dahyak* wheat from Nushki, Chágai, ; *Spín ghanam* and *Sára ghanam* from Bori, Loralai.

Baluchistán Class XXXIII. Ears smaller and less bold and lax than in Class XXXII, fully bearded, awns red ; glumes smooth, pale red with a bluish bloom ; grain medium sized, smaller than in Class XXXII and a paler red in colour.

To this class belongs *Sur ghanam* from Kákar Khorásán, Lower Zhob and similar wheats occurred as admixtures in *Spín ghanam* and *Sára ghanam* from Pishín ; in *khushkába* wheat from Chaman, Quetta-Pishín ; in *Tor ghanam* from Fort Sandeman, Lower Zhob ; in a sample named *Salomon razi* and in four samples from Mach.

Baluchistán Class XXXIV. Ears thin, lax, medium in length, bearded but awns short, awns red ; glumes slightly rounded, smooth, reddish brown ; grain somewhat dark red.

Wheats belonging to this class were found as admixtures in *Pambarin* wheat from Quetta ; *Dahak* wheat from Panjgúr, Makrán and in two samples from Mach.

Baluchistán Class XXXV. Ears short, small, thin, bearded, with very short awns ; glumes rounded, smooth, reddish brown ; grain pale red.

Wheats belonging to this class were found as admixtures in *Kamar* wheat from Pishín, in a sample named *Madar khushkába* and in three samples from Mach.

var. *erythroleucon* Kcke.

Baluchistán Class XXXVI. Ears medium in length and density, fully bearded, awns red ; glumes smooth, brownish red with a bluish bloom ; grain white, somewhat long, normal in shape.

To this belongs *Bujri* from the Nasírábád and Sibi *tahsíls*, Sibi and *Spín ghanam* from Sanjáwi, Loralai. Similar wheats were also found as admixtures in *Thori* wheat from Nasírábád, Sibi and in *Sára ghanam* from Duki, Loralai.

Baluchistán Class XXXVII. Ears medium in density, fully bearded, awns red ; glumes slightly rounded, smooth, pale red with a bluish bloom ; grain white with a distinct hump ; straw strong. To this class belong three samples from Mach and similar wheats were found as admixtures in *Kamar* and *Spín* wheats from Pishín ; in an unnamed sample from Quetta ; in *Sur ghanam* from Kákar Khorásán, Lower Zhob and in four samples from Mach.

Baluchistán Class XXXVIII. Ears medium in length and density, fully bearded, awns red ; glumes smooth, brownish red with no bluish bloom ; grain white, somewhat humped.

To this belong *Wáru* wheat from Dhádar, Kachhi, Kalát; *Rodi* wheat from Bárkhán, Loralai; *Urbsen* wheat from Músa Khél, Loralai and similar wheats belonging to this class were found as admixtures in a sample from Kohlu, Sibi; in *Spín ghanám* from Kila Saifulla, Upper Zhob; in *Laghar, Spín ghanam,* and *Sára ghanam* from Bori, Loralai; in *Toda* and *Pambarin* wheats from Quetta; in *Lakhi* wheat from Bárkhán, Loralai; in *Dahyak* wheat from Nushki, Chágai and in two samples named *Madar khushkába* and *Bati razi.*

Baluchistán Class XXXIX. Ears somewhat lax, bearded but awns very short; glumes somewhat rounded, smooth, brown with a bluish bloom; grain white not humped.

To this belong *Pambarin* wheat from Quetta and seven unnamed samples from Mach, similar wheats occurred as admixtures in two other samples from Mach.

var. *erythrospermum* Kcke.

Baluchistán Class XL. Ears lax, very bold, fully bearded but awns more spreading than in the next two classes; glumes smooth, white; grain dark red, somewhat large, short and humped; straw very strong.

To this class belong *Surbaj* wheat from Quetta, and one sample of *Spín ghanam* from Kákar Khorásán, Zhob. Similar wheats were found as admixtures in *Spín ghanam,* from Hindubágh, Upper Zhob; and in three samples of *Spín ghanam* from Kákar Khorásán, Lower Zhob.

Baluchistán Class XLI. Ears less bold than in Class XL but larger than in Class XLII, lax; awns less spreading than in Class XL but stiffer and shorter than in XLII; chaff smooth, white; grain fairly large, dark red, humped; straw moderately strong, no pink colour.

To this class belong *Soor ghanam* from Sháhrig, Sibi; two samples from Kohlu, Sibi; *Khosha* and *khushkába* wheat from Chaman, Quetta-Pishín; *Spín ghanám* from Duki, Loralai; *Sára ghanam* from Bori, Loralai; *Zizha* wheat from Músa Khél, Loralai; *Lakhi* from Bárkhán, Loralai; *Dahyak* wheat from Dálbandin, Chágai and *Dahyak* wheat from Nushki, Chágai. Similar wheats were found as admixtures in *Spín ghanam* from Sháhrig, Sibi; in *Kamar, Spín, Godewoda* and *Surmani* wheats from Chaman, Quetta-Pishín; in *Sara ghanam* from Sanjáwi, Loralai; in *Laghar* from Bori, Loralai; in *Urbsen* from Músa Khél, Loralai; in *Rodi* from Bárkhán, Loralai; in *Siah das* and *Turki* wheats from Dálbandin, Chágai and in a sample of white wheat from Nushki, Chágai.

Baluchistán Class XLII. Ears medium in density, slender, bearded with long, rather weak awns; chaff smooth, white, both awns and chaff having a pinkish tinge; grain small, pale red, not humped; straw weak, pink in colour, turning black on ripening.

To this class belong *Sra ghanam* from Kila Saifulla, Upper Zhob; *Sra ghanam* from Hindubágh, Upper Zhob; *Sra ghanam* from Fort Sandeman, Lower Zhob; *Bujri* from Nasírábád, Sibi; Red *Toda* from Quetta, Quetta-Pishín; *Wáru* from Dhádar, Kachhi, Kalát; *Thori* from Gandáva, Kachhi, Kalát; *Dahak* and *Shutur dandan* from Panjgúr, Makrán, Kalát. Similar wheats were found in some samples of *Bujri* from Nasírábád, Sibi; in *Wáru* from Gandáva, Kachhi, Kalát; in *Pambarin* and white *Toda* from Quetta, and in *Ghat ghanam* from Fort Sandeman, Lower Zhob.

Baluchistán Class XLIII. Ears fully bearded but awns shorter than in Class XLII whereas the ears are longer and very lax; glumes smooth, white; grain long, dark red; straw not pink.

Wheats belonging to this class were found as admixtures in some samples named *Saloman razi*, *Bati razi*, *Shaderzi*, *Kamar* and *Khuda dadarzi* which all came from the same locality.

Baluchistán Class XLIV. Ears fully bearded, longer and laxer than in Class XLII; grain humped, light red, small.

To this class belong four unnamed samples from Mach, *Kumar* wheat from Pishín, Quetta-Pishín and similar wheats occur as admixtures in six samples from Mach, in *Spín* wheat from Pishín and in an unnamed sample from Quetta, Quetta-Pishín.

Sára wheat from Pishín is very similar to the wheats in this class but has pink straw.

var. *graecum* Kcke.

Baluchistán Class XLV. Ears medium to lax, fully bearded; glumes white, smooth; grain white.

To this class belong *Spín ghanam* from Kákar Khorásán, Lower Zhob; *Surmani* wheat from Chaman, Quetta-Pishín; *Spín ghanam* from Duki, Loralai; *Dholi* wheat from Bárkhán, Loralai; white *Toda* wheat from Quetta, Quetta-Pishín and similar wheats were found as admixtures in *Bujri* from Nasírábád, Sibi; in *Godewoda*, *Kamar ghanam*, *Khushkába ghanam* and *Spín ghanam* from Chaman, Quetta-Pishín; in *Sra ghanam* from Hindubágh and Kila

Saifulla, Upper Zhob; in an unnamed sample from Kohlu, Sibi; in *Shutur dandan* from Panjgúr, Makrán; in *Sára ghanam* from Bori, Loralai; in *Sára ghanam* from Sanjáwi, Loralai; in *Zizha* wheat from Músa Khél, Loralai; in *Lakhi* wheat from Bárkhán, Loralai; in *Pambarin* and red *Toda* wheats from Quetta; in *Wáru* from Dhadar, Kachhi, Kalát; in *Spín*, *Kamar* and *Sára* wheats from Pishín; in two unnamed samples from Quetta; in *Dahyak* wheat from Nushki, Chágai; in nine samples from Mach; in a sample named *Madar khushkába* and in some samples named *Saloman razi*, *Bati razi*, *Shahderzi* and *Kumar*, which all came from the same locality.

var. *pyrothrix* Al.

Baluchistán Class XLVI. Ears medium to long, in density medium to lax; beardless with very short tips; glumes felted, reddish brown; grain small, short, somewhat rounded, pale red; straw strong.

Wheats belonging to this class were found as admixtures in *Thori* and *Phundni* wheats from Nasírábád, Sibi; in *Lal reli* from Sibi *tahsíl*, Sibi; in *Baj* wheat from Dhádar, Kalát; and in *Thori* and *Wáru* wheats from Gandáva, Kachhi, Kalát.

Baluchistán Class XLVII. Ears short, medium to lax, quite beardless; glumes red with a slight bluish bloom; grain short, somewhat rounded, red; straw pink, turning black on ripening. Wheats belonging to this class were found as admixtures in five samples from Mach.

var. *Delfii* Kcke.

Baluchistán Class XLVIII. Ears medium to long, medium in density beardless with small tips; glumes felted, red with a bluish bloom; grain short, small, somewhat rounded, white and generally soft.

To this class belong *Thori* wheat from Nasírábád, Sibi; *Lal Reli* from Sibi *tahsíl*, Sibi; *Baj* wheat from Dhádar, Kalát; *Wáru* wheat from Gandáva, Kachhi, Kalát and similar wheats were found as admixtures in *Phundni* and *Bujri* wheats from Nasírábád, Sibi; in *Borji* wheat from Sibi *tahsíl*, Sibi and in three samples from Mach.

Baluchistán Class XLIX. Ears short, dense, almost like those in *T. compactum*, flattened, with a fan-shaped apex, beardless with short tips; glumes felted, reddish brown with no bloom; grain white.

To this class belong three samples from Mach and a similar wheat was found as an admixture in *Phundni* wheat from Nasírábád, Sibi.

var. *velutinum* Schübl.

Baluchistán Class L. Ears medium to long and medium to dense, beardless with many short tips ; glumes felted, white ; grains small, round, pale red, soft.

Wheat belonging to this class was found as an admixture in *Thori* wheat from Nasírábád, Sibi.

Baluchistán Class LI. Ears medium to long and medium to dense, quite beardless ; glumes felted, white ; grain somewhat small and short, humped, red.

Wheats belonging to this class were found as admixtures in *Thori* wheat from Nasírábád, Sibi and in *Thori* wheat from Gandáva, Kachhi, Kalát.

Baluchistán Class LII. Ears short to medium in length, medium to dense, beardless or with a few small tips ; glumes felted and very white ; grain pale red ; straw pink.

Wheats belonging to this class were found as admixtures in eight samples from Mach.

var. *leucospermum* Kcke.

Baluchistán Class LIII. Ears bold and large, dense with fan-shaped apex, flattened, quite beardless or with tiny tips ; glumes felted, white ; grain very short and small but not humped, white ; straw extremely strong and probably pink.

To this class belongs *Reli* from Dhádar, Kachhi, Kalát and *Turki* from Nushki, Chágai. A similar wheat was found as an admixture in *Wáru* from Gandáva, Kachhi, Kalát.

Baluchistán Class LIV. Ears medium in length and density, beardless or with very small tips ; glumes not rounded, felted, white ; grain short, small but not humped, white ; straw fairly strong, pink.

To this class belong five samples from Mach and similar wheats were also found in three other samples.

Baluchistán Class LV. Ears with well-marked, short tips ; glumes somewhat sharply keeled, felted, white ; grain white, longer than in Class LIV ; straw thin, not pink.

Wheats belonging to this class were found as admixtures in *Thori* and *Phundni* wheats from Nasírábád, Sibi, and in *Thori* wheat from Gandáva, Kachhi, Kalát.

var. *milturum* Al.

Baluchistán Class LVI. Ears medium to dense, beardless except for short tips; glumes smooth, red; grain very pale red; straw strong.

Wheats belonging to this class were found in *Wáru* and *Thori* wheats from Gandáva, Kachhi, Kalát; and in two samples from Mach.

Baluchistán Class LVII. Ears dense, flattened, apex tends to be fan-shaped, beardless with very distinct tips; grain very small, light red; straw strong.

A wheat belonging to this class was found as an admixture in *Thori* wheat from Nasírábád, Sibi.

var. *alborubrum* Koke.

Baluchistán Class LVIII. Ears long, medium to dense, beardless with somewhat long tips; glumes smooth, red with a slight bluish bloom; grain small, short, somewhat rounded but not humped, white; straw medium, pink.

Koto wheat from Kéch, Makrán belongs to this class and similar wheats were found as admixtures in *Thori* and *Bujri* wheats from Nasírábád, Sibi; in *Báj* wheat from Dhádar, Kachhi, Kalát; in *Wáru* wheat from Gandáva, Kachhi, Kalát, and in *Lal reli* wheat from Sibi *tahsíl*, Sibi.

A wheat occurring as an admixture in three samples from Mach probably also belongs to this class but the grain appears slightly longer.

Baluchistán Class LIX. Ears short and dense with a fan-shaped apex, flattened, beardless with distinct tips; glumes pale red with a slight bluish bloom; grain short, small, somewhat round but not humped, white; straw thin to medium.

Phundni wheat from Nasírábád, Sibi, belongs to this class and similar wheats belonging to this class were found as admixtures in *Thori* and *Bujri* wheat from Nasírábád, Sibi.

Baluchistán Class LX. Ears lax, beardless with short tips; glumes rounded, smooth, brownish red; grain small, somewhat humped, not rounded, white.

A wheat belonging to this class was found as an admixture in a sample from Mach.

var. *lutescens* Al.

Baluchistán Class LXI. Ears short, medium in density with short tips; glumes smooth, white; grain short, small not humped, light red; straw pink.

Wheats belonging to this class were found as admixtures in *Thori, Phundni* and *Bujri* wheats from Nasírábád, Sibi; in *Kundai* and *Urbsen* wheats from Músa Khél, Loralai; in *Thori* from Gandáva, Kachhi, Kalát, and in six samples from Mach.

var. *albidum* Al.

Baluchistán Class LXII. Ears medium to lax, beardless with distinct tips; glumes smooth, white; grain white; straw thin, pink.

To this class belong *Thori* wheat from Nasírábád, Sibi, and an unnamed sample from Mach.

Wheats belonging to this class were found as admixtures in *Bujri* and *Phundni* wheats from Nasírábád, Sibi; in *Thori* wheat from Gandáva, Kachhi, Kalát; in six samples from Mach and in *Ghat ghanam* from Fort Sandeman, Lower Zhob.

Baluchistán Class LXIII. Ears dense and very bold, beardless, apex fan-shaped; glumes white, smooth; grain very small and round, white; straw pink and very strong.

A wheat belonging to this class was found as an admixture in *Reli* wheat from Dhádar, Kalát.

Baluchistán Class LXIV. Ears dense and very short, not bold, beardless, apex fan-shaped; glumes smooth, white; grain medium in size, not rounded, white; straw thin.

To this class belongs *Kundai* wheat from Músa Khél, Loralai.

III. THE WHEATS IN EACH DISTRICT.

SIBI.

This District adjoins the Punjab and certain of the *tahsíls* resemble in climate and physical aspects the neighbouring parts of Sind. The District is a large one, 11,281 sq. miles, but only a third of this is directly administered, the rest being under political control only. Great variations in altitude occur. The Sibi and Nasírábád *tahsíls* which abut on Sind form a level plain, never above 500 feet in altitude. The remainder of the District consists of mountainous country with high mountains and narrow valleys, of which the principal are the Harnai valley (56 miles long by 6 miles broad), the Kach valley (4 miles long by 1 mile broad) and the Kowas and Ziarat valleys.

The climate naturally varies with the altitude. The highlands resemble the other places of high elevation in Baluchistán and enjoy a cool summer

but a very cold winter, with their greatest rainfall in the winter months. The plains of Sibi and Nasírábád have a very long, excessively hot summer, and a very scanty rainfall, which occurs mostly in July and August. The Shahríg *tahsíl*, which has an elevation of 2,300—4,500 feet is intermediate in climate. The amount of precipitation varies with the altitude. The average rainfall at Shahríg is 11·51, at Kach 11·06, at Sibi 4·95, and at Babar Kach 6·09 inches.

The only large rivers are the Nári and its tributaries. The permanent water of this river is made available for irrigation purposes in Sibi by means of a masonry regulator erected at Nári gorge in 1904. This replaced the temporary dams which used to be constantly washed away by floods.

Irrigated cultivation predominates; out of a total of 298 villages, 198 are completely secured by irrigation and only 12 are quite unirrigated. Two canals, the Begari canal and the Desert or Shahiwa canal, both from the River Indus, supply Nasírábád. About 90 per cent. of the cultivation in this *tashíl* is dependent on the canals, which are generally filled in June and closed in January. The water is either carried on to the land by gravitation or lifted by a Persian wheel. In the Sháhríg *tahsíl*, springs are the main source of water but a certain number of *kárézes* also exist. In Kohlu, most of the cultivation is carried out on flood irrigation. A few *kárézes* are also found in this locality.

A much larger variety of crops can be grown in this District than in many parts of the Agency, and wheat does not therefore occupy so prominent a position. In the Sibi *tahsíl*, 13,515 acres out of 37,717 acres were under wheat in 1904-05, in Sháhrig 5,793 acres out of 9,777 acres and in Nasírábád 2,656 acres out of 83,739.

In the Sibi and Sháhríg *tahsíls*, wheat is generally grown on irrigated land only, but it may also be grown as a dry crop if the rainfall is exceptionally good. In Nasírábád, very little is grown and in Kohlu it is usually grown as an unirrigated crop.

Manure is commonly used in the Sháhríg *tahsíl*, and the land is often improved by adding the ashes of the burnt stubble of wheat and rice. Wheat and rice are grown in alternate years or successively for two or three years, or *juar* may follow wheat in which case the land requires a fallow. In other parts, manure is not so much used and, instead, the land is allowed to lie fallow for one or more years. In Kohlu, one year fallows are common, while in Nasírábád the land may remain uncropped for two or three years. In the Sibi *tahsíl*, the custom varies in different parts. There may be two crops in three years or one crop in three years or even one crop in five years.

In the plains, wheat is sown in irrigated lands in October and November and reaped in April. In the valleys of high elevation, the land is ploughed in the spring and summer and watered in October. When the land has dried sufficiently, the seed is scattered broadcast and ploughed in. The second watering is given fifteen days after germination, the third about the middle of January and the fourth at the beginning of March. After this the wheat is irrigated every ten or fifteen days.

The average yield of wheat in maunds per acre is as follows :—

	NASIRABAD	SIBI	SHAHRIG	KOHLU
Land irrigated and manured	18·9	–	13·4 to 21·4	–
Land irrigated but not manured	17·5	12·5	–	19
Dry crop land	–	–	13·6	14·5

Nasirábád tahsíl.

I. Thori. Seven samples of this wheat from seven different villages were sent. It is said to be grown for export and to be the best wheat in the District. The name *Thori* signifies bald or without awns. The samples were very mixed and the main constituent was not the same in each. It would appear therefore that *Thori* is not a variety but a group of wheats which resemble one another in being beardless and in having white grain. In three samples, the chief constituent was a beardless wheat with red, felted glumes, in two samples a beardless wheat with smooth, white chaff and one sample had equal quantities of these two. One sample was too unripe and damaged to examine.

1. *Thori from the village of Gandakha.* There were no less than ten different wheats in this sample. The main constituent was a beardless wheat with red, felted chaff and white grain (var. *Delfii* Kcke. Class XLVIII).

2. *Thori from the village of Khudadad.* This sample contained eight different wheats. A beardless wheat with smooth, white chaff, white grain and pink straw was present to the largest extent (var. *albidum* Al. Class LXII).

3. *Thori from the village of Dadpur.* About two-thirds of the sample consisted of a beardless wheat with red, felted chaff and white grain (var. *Delfii* Kcke. Class XLVIII). There were five other wheats present.

4. *Thori from the village of Manjhipur.* About one-third of this sample consisted of the beardless, smooth, white-chaffed wheat (var. *albidum* Al. Class LXII) and one-third of the beardless, felted, red-chaffed wheat (var. *Delfii* Kcke. Class XLVIII). About one-sixth consisted of a beardless wheat with light red, smooth chaff, white grain and pink straw (var. *alborubrum* Kcke. Class LVIII), and another sixth of a similar wheat with no pink colour in the straw and with fan-shaped apices on the ears (var. *alborubrum* Kcke. Class LIX). Three other wheats were present in small quantity.

5. *Thori from the village of Dheeran.* This was a fairly pure sample of the beardless wheat with red, felted chaff and white grain (var. *Delfii* Kcke. Class XLVIII). Three other wheats were present in small quantity.

6. *Thori from the village of Lehri Domki.* This was a fairly pure sample of the beardless wheat with smooth, white chaff (var. *albidum* Al. Class LXII). Four other wheats were present.

The following impurities were present :—

(i) A beardless wheat with long ears, smooth, red chaff, white grain and pink straw (var. *alborubrum* Kcke. Class LVIII) in samples 1, 2, 3, 5 and 6.

(ii) A similar wheat without pink straw and with short, dense ears with fan-shaped apices (var. *alborubrum* Kcke. Class LIX) in samples 1, 2, 3 and 4.

(iii) A beardless wheat with rounded, smooth, white glumes, and small red grain (var. *lutescens* Al. Class LXI) in samples 1, 2, 3 and 6.

(iv) A beardless wheat with white, felted chaff and white grain (var. *leucospermum* Kcke. Class LV) in samples 2 and 6.

(v) A beardless wheat with dense ears, smooth, red glumes and small, bright red grain (var. *milturum* Al. Class LVII) in sample 1.

(vi) A beardless wheat with small tips, white, felted glumes and small, pale red grain (var. *velutinum* Schübl. Class L) in sample 1.

(vii) A similar wheat with quite beardless ears (var. *velutinum* Schübl. Class LI) in sample 2.

(viii) A beardless wheat with felted, red glumes and red grain (var. *pyrothrix* Al. Class XLVI) in samples 1, 3, 4 and 5.

(ix) A fully bearded wheat with smooth, white glumes and white grain (var. *graecum* Kcke. Class XLV).

(x) A fully bearded wheat with smooth, red glumes and white grain (var. *erythroleucon* Kcke. Class XXXVI) in samples 1 and 3.

(xi) A fully bearded wheat with white, felted glumes and white grain (var. *meridionale* Kcke. Class XXVI) in sample 3.

(xii) A bearded wheat with black awns, felted, greyish white chaff and pale red grain (var. *fuliginosum* Al. Class XX).

(xiii) A bearded wheat with short, dense ears, red, felted, rounded glumes and red grain (var. *barbarossa* Al. Class XIV) in sample 1.

II. Phundni. This is said to be very similar to *Thori* and is quite as good in quality. It is generally exported and has the same market value as *Thori.* Irrigated land is used for the cultivation. Only one sample of this wheat was received. The ears are beardless and dense with fan-shaped apices. The chaff is smooth, light red with a bluish bloom and the grain is white. The straw is pink, turning black on ripening (var. *alborubrum* Kcke. Class LIX). There were also present in fair quantity, as impurities, two beardless wheats with red, felted chaff and white grain (var. *Delfii* Kcke. Class XLVIII and Class XLIX), and in small quantity a similar wheat with red grain (var. *pyrothrix* Al. Class XLVI) ; a beardless wheat with smooth, white chaff and white grain (var. *albidum* Al. Class LXII) ; a similar wheat with red grain (var. *lutescens* Al. Class LXI) ; and a beardless wheat with white, densely felted chaff and white grain (var. *leucospermum* Al. Class LV).

III. Bujri. This variety is considered to be of inferior quality and is cheaper than *Thori* or *Phundni.* Six samples were received very different in composition. "*Bujri*" which means "bearded" is the name of a group of wheats rather than of any particular variety.

In three samples, the main constituent was a fully bearded wheat with smooth, red glumes and white grain, in one sample it was a similar wheat with white chaff. One sample was a mixture in equal parts of a bearded wheat with smooth, white chaff and white grain, and of a similar wheat with red grain. The sixth sample was a mixture of all these four wheats.

1. *Bujri from the village of Khanpur.* This sample was a mixture of two bearded wheats with smooth, white chaff, the one with white grain (var. *graecum* Kcke. Class XLV), the other with red grain (var. *erythrospermum* Kcke. Class XLII). There was only one impurity—a bearded wheat with black awns, white, felted glumes and red grain (var. *fuliginosum* Al. Class XX).

2. *Bujri from the village of Dheeran.* Almost the whole of this sample consisted of a bearded wheat with large, lax ears, smooth, red glumes, white grain and strong straw (var. *erythroleucon* Kcke. Class XXXVI). There were

present as impurities in small quantity the two constituents of sample 1 and a bearded wheat with red, felted glumes and white grain (var. *turcicum* Kcke. Class XVI).

3. *Bujri from the village of Dhadpur.* One-third of this sample consisted of the same wheat as in 1, one-third of a bearded wheat with black awns, greyish white, felted chaff and red grain (var. *fuliginosum* Al. Class XX), one-sixth of a bearded wheat with smooth, white chaff and white grain (var. *graecum* Kcke. Class XLV), and one-sixth of a similar wheat with red grain (var. *erythrospermum* Kcke. Class XLII). There was also a small quantity of a bearded wheat with smooth, red glumes and red grain (var. *ferrugineum* Al. Class XXXII).

4. *Bujri from the village of Garhi Mir Muhamed.* Three-quarters of this sample consisted of a fully bearded wheat with lax ears, smooth, white glumes, dark red grain and weak, pink straw which turns black on ripening (var. *erythrospermum* Kcke. Class XLII). The rest of the sample was composed of a bearded wheat with white, felted glumes, strong straw and red grain (var. *Hostianum* Clem. Class XXI).

5. *Bujri from the village of Khudadad.* This was a very mixed sample, no less than nine wheats being present. About half the sample was composed of the bearded wheat with smooth, red glumes and white grain found in sample 2 (var. *erythroleucon* Kcke. Class XXXVI). The two main constituents of sample 1 formed each about one-fifth of the sample (var. *graecum* Kcke. Class XLV) and (var. *erythospermum* Kcke. Class XLII). There were also present in small quantity a bearded wheat with white, felted glumes and red grain (var. *Hostianum* Clem. Class XXI); a similar wheat with white grain (var. *meridionale* Kcke. Class XXVI); a bearded wheat with smooth, red glumes and red grain (var. *ferrugineum* Al. Class XXXII); a beardless wheat with red, felted glumes and white grain (var. *Delfii* Kcke. Class XLVIII); two beardless wheat with smooth, red glumes and white grain (var. *alborubrum* Kcke. Class LVIII and Class LIX); a beardless wheat with smooth, white glumes and white grain (var. *albidum* Al. Class LXII).

6. *Bujri from the village of Faizabad.* This resembled sample 5.

Sibi tahsíl.

Two samples were received from this *tahsíl.*

IV. Kahani or Bujri. This is a bearded wheat with smooth, red chaff and white grain (var. *erythroleucon* Kcke. Class XXXVI), similar to some of the

samples of *Bujri* from Nasirábád. There were also present as impurities in small quantity a similar wheat with red grain (var. *ferrugineum* Al. Class XXXII); a bearded wheat with red, densely felted chaff and white grain (var. *turcicum* Kcke. Class XV), and a beardless wheat with red, felted chaff and white grain (var. *Delfii* Kcke. Class XLVIII).

V. Lal réli. This is a beardless wheat with red, felted glumes and white grain (var. *Delfii* Kcke. Class XLVIII). There were also present in small quantity a similar wheat with red grain (var. *pyrothrix* Al. Class XLVI) and a beardless wheat with smooth, red chaff and white grain (var. *alborubrum* Kcke. Class LVIII).

Kohlu sub-tahsíl.

Two samples were sent from this locality, one grown on irrigated and the other on unirrigated land. There is no distinctive name for this wheat.

VI. Sample A, grown on irrigated land. The sample was mainly composed of a bearded wheat with smooth, white glumes and red grain (var. *erythrospermum* Kcke. Class XLII). Two other wheats were present as impurities: a bearded wheat with smooth, white chaff and white grain (var. *graecum* Kcke. Class XLV) and a bearded wheat with smooth, dark red chaff and white grain (var. *erythroleucon* Kcke. Class XXXVIII).

VII. Sample B, grown on unirrigated land. This consisted of a mixture in equal parts of the main constituent of sample A and of a bearded wheat with smooth, bright red chaff and red grain (var. *ferrugineum* Al. Class XXXII.)

Shahríg tahsíl.

Three samples were received from this *tahsíl*.

VIII. Spín ghanam, lasidar, starchy white wheat or *Balu Ali*, sandy wheat. It is only grown on irrigated land. This sample was a mixture in equal parts of a rivet wheat and a common wheat. The rivet wheat had smooth, white glumes with a peculiar ridge on the outer glumes and large, plump, white grain (var. *nemausense* Wittm. Class III). The other constituent was a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLII).

IX. Spín ghanam, Be lasidar, white wheat without starch. This is a bearded wheat with short awns, very rounded, greyish-white, felted glumes and white grain. The straw is very strong almost solid (var. *meridionale* Kcke. Class XXIX).

X. *Soor ghanam,* red wheat. This variety is grown both on irrigated and unirrigated land. The ears are bearded, the chaff smooth and white and the grain red (var. *erythrospermum* Kcke. Class XLII). Two wheats were present in small quantities as impurities, a bearded wheat with red, felted glumes and white grain (var. *turcicum* Kcke. Class XV) and a bearded wheat with smooth, red chaff and red grain (var. *ferrugineum* Al. Class XXXII).

BOLAN PASS.

This District includes the Bolán Pass proper and the lands occupied by the Mushkáf-Bolán and Quetta-Nushki Railways. It forms a long, narrow strip of country 60 miles long with a change in altitude from 463 feet at the southern end (Rindli) to 5,793 feet at the upper end (Dhast). The District is mountainous with long, narrow valleys and of the 900 square miles only a very small portion is cultivable.

The climate varies with the altitude ; the summer is extremely hot in the lower parts of the Pass and the winter very severe above Mach. A strong north wind blows constantly but is strongest in January, February and March causing damage to the wheat crop. The average rainfall in the upper part of the valley is 7·64 inches which falls mainly between December and March ; at Panèrband, on the other hand, most of the rain falls in the summer months and the average annual rainfall is 4 inches. The cultivated area lies mainly in the lower two-thirds of the valley, in the valleys and flats between the mountains, and the rainfall at Panir represents that of these areas.

The irrigated land lies chiefly round Rindli, Kirta, Kundalam, Bíbi Nani, Píshi and in the bed of the river between Mach and Kolpur while the dry crop lands are principally at Takari, Toba, Panérband, Sàhibdàd Thal, Chirak and Zámuri. The Bolán River with its springs and the Mach hill torrent are the main sources of water. The irrigated area at Kirta is about 3,135 acres, at Rindli 27 acres and at Mach 7 acres while the dry crop area is about 800 acres.

The spring harvest on irrigated land which constitutes at about 58 per cent. of the whole cultivation consists mainly of wheat. No records of the outturn are available. The dry crop land is generally under wheat if the rainfall is sufficient. The time of sowing varies with the altitude. On irrigated land the seed is sown broadcast between October and December. It is either sown in the dry land and then watered or the land is watered first and then sown. If possible it is watered again as soon as it has

germinated and then at intervals of about twenty days. It is cropped in January for fodder and harvested in early May.

The following is the description given in the *Bolan Gazetteer* of the varieties grown:

"The wheat sown in the District is of seven varieties: *bárkhami* the seed of which, as the name implies, was originally imported from Bárkhán in the Loralai District about the year 1885; *talmalo*, a new variety imported from Narmuk about 1901, the grain of which is larger and thicker than that of *bárkhami; suhr-bij*, the indigenous variety; *réli*, a kind introduced from India since the opening of the railway; *sangsíla* introduced from the Bugti country; *káréz ná bíj*, also known as *pazhmi*, a white variety, the seed of which has been imported from Marav in Sarawán; and *wáru*, a red wheat also said to be indigenous. *Wáru* is an inferior sort and is now seldom cultivated. *Bárkhami* and *talmalo* are now (1905) most popular."

A very large number of samples were received from the Bolán but unfortunately none of them were labelled, and it is therefore impossible to identify them with the varieties mentioned above. The samples were somewhat unlike the other Baluchistán wheats and seemed to form a separate group. Many had pink straw and very rounded glumes. The ears on the whole were thin and very lax.

The twenty-three samples received belonged to seven different types. (This refers only to the bulk of the sample and not to the wheats present as accidental impurities.)

Three samples belonged to var. *meridionale* Kcke. Class XXVIII (ears partly bearded; glumes white, felted, rounded; grain white, short and very humped).

1. *Sample 1.* Five-sixths of the bundle belonged to the above class and there were present in small quantities, as accidental impurities, a fully bearded wheat with white, felted glumes, red grain and pink straw (var. *Hostianum* Clem. Class XXIII); a fully bearded wheat with smooth, white chaff, white grain and pink straw (var. *graecum* Kcke. Class XLV) and a partly bearded wheat with smooth, red chaff and white grain (var. *erytholeucon* Kcke. Class XXXIX).

2. *Sample 2.* Three-quarters of the bundle belonged to Class XXVIII and there were four other wheats present as impurities: a fully bearded wheat with white, felted glumes and red grain (var. *Hostianum* Clem. Class XXII); a fully bearded wheat with smooth, white chaff and red grain

(var. *erythrospermum* Kcke. Class XLIV); a similar wheat with white grain (var. *graecum* Kcke. Class XLV) and one ear of a beardless wheat with smooth, red chaff and white grain (var. *alborubrum* Kcke. Class LX).

3. *Sample 3.* Three-quarters of the sample belonged to Class XXVIII and there were present in small quantity a fully bearded wheat with white, felted chaff and red grain (var. *Hostianum* Clem. Class XXIII); a fully bearded wheat with smooth, white chaff and white grain (var. *graecum* Kcke. Class XLV) and a similar wheat with red grain (var. *erythrospermum* Kcke. Class XLIV).

Nine samples (Nos. 4—12) belonged to var. *erythroleucon* Kcke. (bearded wheats with smooth, red glumes and white grain) and of these, three samples (4, 5 and 6) belonged to Class XXXVII (ears fully bearded, grain with distinct hump) and six belonged to Class XXXIX (ears partly bearded, grain without a hump).

4, 5. *Samples 4 and 5* were very nearly pure but in both samples there was a small quantity of a fully bearded wheat with smooth, red chaff and red grain (var. *ferrugineum* Al. Class XXXIII), and in sample 5 there were also small quantities of a fully bearded wheat with red, felted chaff and red grain (var. *barbarossa* Al. Class XIV), as well as of a fully bearded wheat with smooth, white chaff and white grain (var. *graecum* Kcke. Class XLV).

6. In *Sample 6*, three-quarters of the sample belonged to Class XXXVII, and the following wheats were present in small quantities: a bearded wheat with white, felted glumes, white awns and red grain (var. *Hostianum* Clem. Class XXIII); a bearded wheat, with smooth white glumes and red grain (var. *erythrospermum* Kcke. Class XLIV); a bearded wheat with smooth, white glumes and white grain (var. *graecum* Kcke. Class XLV); a beardless wheat with red, felted glumes and white grain (var. *Delfii* Kcke. Class XLVIII); a beardless wheat with white, felted glumes and red grain (var. *velutinum* Schübl. Class LII); a beardless wheat with felted, white glumes and white grain (var. *leucospermum* Kcke. Class LIV), and the same wheat belonging to var. *ferrugineum* Al. Class XXXIII, which was present in samples 4 and 5.

7, 8, 9. In the samples belonging to Class XXXIX, sample 9 was quite pure and samples 7 and 8 practically so, only single ears of a partly bearded wheat with smooth, red glumes and red grain (var. *ferrugineum* Al. Class XXXV) being found in them.

10. In *Sample 10*, seven-eighths belonged to Class XXXIX and the following wheats were present in small quantities: a wheat similar to samples

4, 5 and 6; a bearded wheat with red, felted glumes and red grain (var. *barbarossa* Al. Class XIII); a similar wheat with white grain (var. *turcicum* Kcke. Class XVII) and the same wheat belonging to var. *ferrugineum* Al. Class XXXV which was present in samples 7 and 8.

11. *Sample 11* was almost pure but a few ears of the following were present: a bearded wheat with smooth, red glumes and red grain (var. *ferrugineum* Al. Class XXXIV); a partly bearded wheat with felted, red chaff and white grain (var. *turcicum* Kcke. Class XVII); a fully bearded wheat with white, felted chaff and white grain (var. *meridionale* Kcke. Class XXVII), and a partly bearded wheat with white, felted chaff and white grain (var. *meridionale* Kcke. Class XXX).

12. In *Sample 12* seven-eighths of the bundle belonged to the type and the following wheats were present in small quantities: a wheat similar to samples 4, 5 and 6, a partly bearded wheat with smooth, red glumes and white grain (var. *ferrugineum* Al. Class XXXIV); a fully bearded wheat with white, smooth chaff and white grain (var. *graecum* Kcke. Class XLV); a similar wheat with red grain (var. *erythrospermum* Kcke. Class XLIV); a fully bearded wheat with white, felted chaff and red grain (var. *Hostianum* Clem. Class XXII), and a partly bearded wheat with white, felted chaff and red grain (var. *Hostianum* Clem. Class XXIV).

Three samples belonged to var. *erythrospermum* Kcke. Class XLIV (ears bearded, long and lax; chaff smooth, white; grain red). All the three samples were very mixed and less than half belonged to the type.

13. In *Sample 13*, about half was true to type, and about one-quarter consisted of a somewhat similar wheat but with white grain, strong straw and lax, bold heads (var. *graecum* Kcke. Class XLV). There were also present in fair quantity: a fully bearded wheat with white, felted chaff and red grain (var. *Hostianum* Clem. Class XXII) and the wheat of which samples 4, 5 and 6 consisted. A very small quantity of a fully bearded wheat with red, smooth chaff and red grain (var. *ferrugineum* Al. Class XXXIII) was also found.

14. In *Sample 14*, only one-third of the sample resembled the type, while one-quarter consisted, as in sample 13, of a somewhat similar wheat with white grain, stronger straw and larger ears (var. *graecum* Kcke. Class XLV). The same three impurities occurred in this sample as in sample 12 and in addition a small quantity of a fully bearded wheat with white, felted chaff and white grain (var. *meridionale* Kcke. Class XXVII).

15. *Sample 15* consisted of three wheats in about equal quantities: the bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLIV) which formed the bulk of samples 13 and 14; the somewhat similar wheat with white grain, stronger straw and larger ears (var. *graecum* Kcke. Class XLV), which formed the chief impurity in these samples, and a partly bearded wheat with white, felted chaff and white grain (var. *meridionale* Kcke. Class XXVIII). There was also present in very small quantity a fully bearded wheat with felted, white chaff and red grain (var. *Hostianum* Clem. Class XXII).

Two samples 16 and 17 belonged to var. *Delfii* Kcke. Class XLIX (beardless wheats with short, dense ears; felted, red glumes and white grain).

16. Seven-eighths of *Sample 16* resembled the type; the remainder consisted mostly of a similar wheat with red grain (var. *pyrothrix* Al. Class XLVII). There were also present in small quantity two beardless wheats with smooth, red chaff; one with red grain (var. *milturum* Al. Class LVI) and the other with white grain (var. *alborubrum* Kcke. Class LVIII).

17. *Sample 17* was very mixed and contained no less than nine distinct wheats. One-third of the bundle resembled the type, one-quarter the main impurity of sample 16 and one-quarter consisted of a beardless wheat with smooth, red chaff and white grain (var. *alborubrum* Kcke. Class LVIII). There were also present in small quantity the following wheats: a bearded wheat with smooth, red chaff and red grain (var. *milturum* Al. Class LVI); a beardless wheat with smooth, white chaff and white grain (var. *albidum* Al. Class LXII); a beardless wheat with white, felted chaff and white grain (var. *leucospermum* Kcke. Class LIV); a similar wheat with red grain (var. *velutinum* Schübl. Class LII), and two bearded wheats (one fully bearded and one partly bearded) with smooth, red chaff and white grain (var. *erythroleucon* Kcke. Classes XXXVII and XXXIX).

18, 19, 20, 21. Four samples consisted mainly of a beardless wheat with white, felted chaff, white grain and pink straw (var. *leucospermum* Kcke. Class LIV). Seven-eighths of the samples 18 and 19 consisted of this type and nine-tenths of the samples 20 and 21 but only one-third of sample 21 which was very mixed. The following wheats were present as impurities in all five samples; a beardless wheat with felted, white glumes and red grain (var. *velutinum* Schübl. Class LII); a beardless wheat with smooth, white

chaff and white grain (var. *albidum* Al. Class LXII); a beardless wheat with smooth, red chaff and white grain (var. *alborubrum* Kcke. Class LX). In samples 19 and 22 there was also present a beardless wheat with felted, red glumes and red grain (var. *pyrothrix* Al. Class XLVII). A beardless wheat with smooth, red glumes and white grain (var. *alborubrum* Kcke. Class LVIII) was present only in sample 20.

22. *Sample 22* which was very mixed contained in addition to the above impurities two wheats, a beardless wheat with red, felted glumes and white grain (var. *Delfii* Kcke. Class XLVIII) and a bearded wheat with smooth, white glumes and red grain (var. *erythrospermum* Kcke. Class XLIV).

23. *Sample 23* was exceedingly mixed and it was difficult to know which was the main constituent. One-sixth of the sample consisted of a beardless wheat with smooth, white chaff and white grain (var. *albidum* Al. Class LXII); one-sixth consisted of a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLIV); one-sixth consisted of a beardless wheat with white, felted chaff and white grain (var. *leucospermum* Kcke. Class LIV). There were also present, in fair quantity, a similar wheat with red grain (var. *velutinum* Schübl. Class LII); a fully bearded wheat with white, felted chaff and red grain (var. *Hostianum* Clem. Class XXIII) and a beardless wheat with smooth, white chaff and red grain (var. *lutescens* Al. Class LX); in small quantity a beardless wheat with felted, red chaff and red grain (var. *pyrothrix* Al. Class XLVII) and a similar wheat with white grain (var. *Delfii* Kcke. Class XLVIII).

QUETTA-PISHIN.

The Quetta-Pishin District is one of the best irrigated Districts in Baluchistán and has therefore the largest cultivated area. It lies centrally in the highland part of Baluchistán with an area of 5,127 square miles. The general character of the District is mountainous with long, narrow valleys. All the valleys are flat plains, 4 to 20 miles in width, with pebbly slopes rising to the mountains. The Pishín plain is the largest of the valleys and others of importance are Loé Toba, the Quetta valley, the Aghbarg valley, and the Gwál valley.

Generally speaking, the climate is fairly uniform over the whole District but varies somewhat with the altitude. In Toba, the seasons begin a month later than in Quetta while Pishín and Chaman are decidedly warmer. The winter is very cold, with snow and biting cold winds, while the summer is hot

at Chaman and Pishín, moderately hot at Quetta and cool at Toba. The average temperatures of Chaman and Quetta are shown in the following table :—

		January		May		July		November	
Station.	*Altitude*	*Mean.*	*Diurnal range.*	*Mean.*	*Diurnal range.*	*Mean.*	*Diurnal range.*	*Mean.*	*Diurnal range.*
Chaman	4,311′	43·2	18·1	79·6	27·4	88·3	26·6	57·6	24·5
Quetta	5,502′	40·0	21·8	67·8	31·4	78·7	27·9	48·7	32·7

The temperatures of Pishín lie between those of Chaman and Quetta.

The rainfall is irregular and occurs mostly in the winter. It is due to storms from the Persian plateau and may consist of either rain or snow. Most of the rain and snow falls in January and February but the storms vary in number and period from year to year. It is more important that there should be good snow than good rain as the rain runs off the slopes very quickly in the form of floods and does not benefit the *kárézes*, springs and streams as much as the snow. Moreover, the vapour tension of snow being lower than that of water, the snow protects the land from drying. The average annual rainfall in Quetta is 10·52 inches, in Pishín 8·69, and in Chaman just over 7 inches.

The whole District is very liable to strong winds—Chaman was reported to have calm weather at 8 A.M. on only twelve days in the whole year.

There are two rivers with many tributaries, the Kadanai which drains the Toba plateau and flows into Afghánistán and the Pishín Lora which, with its tributaries, waters the remainder of the District and passes into Chágai. The water of the main stream of the Kadanai is salt and is said to be injurious to crops. It is, however, raised by earthen dams in some parts and used for irrigation purposes. The Táshrobát, a tributary of the Kadanai, with its own tributaries the Jilja, Hésanna, Gwál, and Zémal supplies most of the water for the irrigated area on the Toba plateau. This consists of patches along the banks of streams on the skirts of the hills.

In the Chaman Subdivision, the main cultivated tracts are Loé Toba, Tabina and the Sahara, the plain round the town of Chaman. Most of this is dry crop cultivation, but there are patches of irrigated cultivation near springs and streams and in ravines. In Pishín there are large dry crop areas in the level plain itself and tracts of land irrigated by the Government canal of Shébo and the Kushdil Khán Reservoir and by *kárézes*, springs and streams. In the Barshor tract, where water is abundant, most of the cultivation is carried out on terraced fields. In the Quetta *tahsíl*, both dry crop cultivation and irrigation from *kárézes*, springs and streams are found. In 1902-03 in the two *tahsíls* of Quetta and Pishín, the irrigated area represented 31 per cent. of

the total cultivable area and 68 per cent. of the area actually cultivated (2,07,317 acres).

Wheat is the most important crop grown and forms almost the whole of the spring harvest. The method of growing it as a dry crop varies in the different parts of the District. In Quetta, the lands are embanked and are filled with flood water when available, either in late summer or in winter. The land is then ploughed and sown. Good summer rain is necessary to fill the embankments, if a satisfactory yield is to be obtained ; later sowing results both in a diminished yield and in a smaller proportion of straw. In Pishín and Toba, the land is not embanked and sowing only takes place after rain. In some parts of Quetta and Pishín, the land is prepared in September and October, the seed sown in the dry ground and left until the next rain causes it to germinate. In all cases, the yield on dry crop lands depends on good spring rains. Dry crop lands are not manured and are generally cultivated every year. The yield is about five maunds an acre. Sowing for dry crop wheat may be continued into the spring, especially in Toba.

Irrigated lands are usually only cultivated every second or third year. This is probably connected with the aeration of the land. Under the system of continual watering in vogue, the land becomes very compacted, and no aeration is possible. Dry crop land, on the other hand, which is not irrigated and in which aeration can take place is cultivated every year. In the neighbourhood of Quetta, the wheat land is generally heavily manured. The irrigated land is ploughed twice during the fallow, once in the spring and once in June. It is watered in September ; the seed is sown broadcast and then ploughed in. The first watering takes place forty days after sowing, the second about the last week in December, and the third at the end of February. The fourth watering is not given till the middle of April and after this the crop is watered regularly at intervals of ten to fifteen days. Harvest takes place in June and July according to the locality. The yield on irrigated, manured land varies from 15 to 25 maunds and in irrigated, unmanured land from 10 to 16 maunds per acre.

The following account of the varieties of wheat grown is given in the Quetta-Pishín *Gazetteer* :—

"The wheat grown in the District is of two kinds, called respectively *da sára ghanam* and *da tauda ghanam ;* each kind in its turn consists of a white and red variety, locally known as *spín* and *súr ghanam.* The seed of the *sára spín ghanam* (winter white wheat) is said to have been originally imported from Garmsél in Afghánistán, while the red variety is said to be indigenous

to Quetta. The seed of the *tauda* (summer or hot) wheat, both white and red, was imported from Shoráwak in Afghánistán ; hence it is also called *shoráwaki ghanam*. For their own consumption, the people prefer the red wheat, but the white is much grown because it fetches the best price of all. Winter (*sára*) wheat ripens in about nine months and *tauda* in a little more than half that period."

Eighteen samples of wheat were received from the Quetta-Pishín District, eight from the Quetta Sub-division, seven from the Chaman Sub-division, and three from Pishín.

Quetta Sub-division.

1. *Pambarin*, a white wheat with a white spike. This wheat is said to be grown both on irrigated land and as a dry crop. Some of the crop is used for food and the rest sold. As a rule, the cultivators prefer a red-grained wheat for their own use but white wheats fetch a higher price. This is a bearded wheat with very rounded, white, densely felted glumes with white grain (var. *meridionale* Kcke. Class XXVIII). There was also present as an impurity a similar wheat with red grain (var. *Hostianum* Clem. Class XXIII) and one ear of a fully bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLII).

The above sample was from irrigated land ; another sample was sent from *khushkába* land which was not so pure. One-third of the bundle was the true *Pambarin* wheat, one-third consisted of a bearded wheat with smooth, white chaff and white grain (var. *graecum* Kcke. Class XLV), and the rest was composed of the two wheats present as impurities above.

2. *Pambarin*, a white wheat with a red spike. This is also grown both on irrigated and dry crop lands. It is a wheat with short awns and small heads, smooth, reddish brown chaff and white grain (var. *erythroleucon* Kcke. Class XXXIX). About one-fifth of the sample consisted of a somewhat similar wheat but with fully bearded ears and larger grain (var. *erythroleucon* Kcke. Class XXXVIII). There was also present in small quantity a wheat similar to the type but with red grain (var. *ferrugineum* Al. Class XXXIV).

3. *Surbaj*. This is a cheaper wheat than either of the two *Pambarins* and the whole is used by the *zamindars* as food. It is grown on irrigated land. It is a bearded wheat with very lax, bold heads and spreading awns, white, smooth chaff, red grain and very strong straw (var. *erythrospermum* Kcke. Class XL). There were no impurities in this sample.

4. *Toda.* A red wheat with a white spike from Shoráwak. Both this and the white *Toda* (sample 5) mature with very little water, and if there are no early rains and cultivation is done late in the season, then about five-sixths of the whole *khushkába* area is put under these two wheats. This is a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLII). There were also present as impurities a similar wheat with white grain, the white *Toda* (var. *graecum* Kcke. Class XLV) and a bearded wheat with smooth, red chaff and white grain (var. *erythroleucon* Kcke. Class XXXVIII).

5. *Toda.* A white wheat with a white spike from Shoráwak. This is similar to the red Toda but has a white grain (var. *graecum* Kcke. Class XLV). There were also present as impurities in small quantity: some red Toda; a bearded wheat with black awns, white, felted chaff and red grain (var. *fuliginosum* Al. Class XIX); a bearded wheat with white, densely felted chaff and white grain (var. *meridionale* Kcke. Class XXVI) and a similar wheat with red grain (var. *Hostianum* Clem. Class XXI).

6. *Shutr dandan* (shaped like a camel's tooth). This is very rarely grown and always only in very small quantity on irrigated land. It is not ground into flour but is parched and chewed. No sample was sent so that no identification was possible.

Both *Pambarins* and *Surbaj* are said to be more liable to rust than the two *Toda* wheats, but whether this is really true or whether it is due to the fact that rust is generally less on the *khushkába* lands on which the *Toda* wheats are grown it is difficult to say.

Two other unnamed samples were received from Quetta. They resembled in every particular *spín* wheat from Pishín.

7. *Unnamed sample, probably spín wheat.* Three-quarters of the bundle consisted of a wheat with lax ears, short awns, rounded glumes and white grain (var. *meridionale* Kcke. Class XXVIII). Nearly a quarter of the sample consisted of the fully bearded, smooth, red chaffed wheat with red grain (var. *erythrospermum* Kcke. Class XLIV). There were also present in very small quantity a wheat similar to the last but with white chaff and white grain (var. *graecum* Kcke. Class XLV); a bearded wheat with felted, white chaff and red grain (var. *Hostianum* Clem. Class XXIII), and a fully bearded wheat with smooth, red chaff and white grain (var. *meridionale* Kcke. Class XXXVII).

8. *An unnamed sample probably spín.* Three-quarters of the sample resembled *spín* wheat from Pishín (var. *meridionale* Kcke. Class XXVIII)

and there were present as impurities : a fully bearded wheat with white, felted chaff and red grain (var. *Hostianum* Clem. Class XXIII) ; a fully bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Keke. Class XLII), and a similar wheat with white grain (var. *graecum* Keke. Class XLV).

Chaman Sub-division.

9. *Kali ghanam.* This is grown on irrigated land and is said to be rarely attacked by rust. It is a common wheat with square heads and much rounded glumes. The chaff is white and felted and the grain white. The bearding was difficult to determine. There appeared to be every stage between almost beardless ears to bearded (var. *meridionale* Keke. Class XXVIII). There were also present as impurities a similar wheat with red grain (var. *Hostianum* Clem. Class XXI) and a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Keke. Class XLI).

10. *Kamar* (white and red seed mixed). This is also grown on irrigated land. Most of the sample consisted of a bearded wheat with sharply keeled glumes, white, densely felted chaff and white grain (var. *meridionale* Keke. Class XXVI). There was also present a fair quantity of a similar wheat but very slightly bearded and with very rounded glumes (var. *meridionale* Keke. Class XXVIII). Other impurities were : a bearded wheat with short awns, white, felted chaff and red grain (var. *fuliginosum* Al. Class XVIII) : a bearded wheat with smooth, white glumes and red grain (var. *erythrospermum* Keke. Class XLII) ; a similar wheat with white grain (var. *graecum* Keke. Class XLV), and a slightly bearded wheat with rounded, white, densely felted glumes and red grain (var. *Hostianum* Clem. Cla s XXV). It will be seen that though the sample was labelled white and red grain the number of red grained ears was very small and did not form more than 5 per cent. of the whole. *Kamar* wheat is said to be rarely attacked by rust.

11. *Surmani.* This wheat is grown mostly in Toba on both irrigated and unirrigated land. It is said to be very liable to rust. Three-quarters of the sample consisted of a bearded wheat with small ears, smooth, white chaff, white grain and weak straw (var. *graecum* Keke. Class XLV). The rest of the sample consisted of a similar wheat with red grain (var. *erythrospermum* Keke. Class XLII).

12. *Khosha* is grown both on irrigated and unirrigated land and is fairly rust-resistant. It is a bearded wheat with smooth, white chaff and red grain

(var. *erythrospermum* Kcke. Class XLII). There were no impurities in this sample.

13. *Godewoda*. This kind is grown only on irrigated land and is said to be very liable to rust. It is difficult to know which of the constituents of this sample is the real *godewoda*. About half the ears resembled the sample of *Kali ghanam* (var. *meridionale* Kcke. Class XXVIII) and about half consisted of a fully bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLII). There were also present in very small quantity a fully bearded wheat with white, felted glumes and red grain (var. *Hostianum* Clem. Class XXIII) and a bearded wheat with smooth, white chaff and white grain (var. *graecum* Kcke. Class XLV).

14. *Spín ghanam*. This kind is only grown on irrigated land and is fairly rust-resistant. It is a slightly bearded wheat with white, densely felted chaff, white grain and very rounded glumes. The straw is fairly strong (var. *meridionale* Kcke. Class XXVIII). There were also present as impurities a fully bearded wheat with white, densely felted chaff and white grain (var. *meridionale* Kcke. Class XXVI) ; a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLI) and a bearded wheat with smooth, white chaff and white grain (var. *graecum* Kcke. Class XLV).

15. *Khushkába ghanam*, wheat from unirrigated land. This sample consisted mainly of a fully bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLII). There were also present a similar wheat with red grain (var. *ferrugineum* Al. Class XXXIII) and a bearded wheat with smooth, white chaff and white grain (var. *graecum* Kcke. Class XLV.)

Pishin tahsíl.

16. *Spín* (white wheat). This kind is grown on irrigated land. The grain is used as food by the wealthy classes or is sold. This sample was very mixed, about one-half consisted of a wheat with medium to lax ears, very short awns, rounded glumes, white humped grain and strong straw (var. *meridionale* Kcke. Class XXVIII). There was also a fair quantity of a very similar wheat but with longer awns, weak straw and sharply keeled glumes (var. *meridionale* Kcke. Class XXVII). A large part of the sample (about one-third) consisted of a fully bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLIV). There were also present as impurities but in small quantity a wheat similar to the last but

with white grain (var. *graecum* Keke. Class XLV); a fully bearded wheat with smooth, red chaff and white grain (var. *erythroleucon* Keke. Class XXVIII): a similar wheat with red grain (var. *ferrugineum* Al. Class XXXIII), and a wheat with partly bearded ears, rounded glumes, felted, white chaff and red grain (var. *Hostianum* Clem. Class XXIII).

17. *Kamar* (white and red). This is also grown on irrigated land. The sample consisted of a mixture in almost equal parts of a fully bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Keke. Class XLIV) and a white wheat exactly like the main constituent of *Spín*. There was also present in fair quantity the wheat resembling *Spín* but with longer awns and sharply keeled glumes (var. *meridionale* Keke. Class XXVII). Thus the samples of *Kamar* and *Spín* contained the same three constituents but in varying proportions. There were also present as impurities in small quantity: a fully bearded wheat with smooth, white chaff and white grain (var. *graecum* Keke. Class XLV); a fully bearded wheat with white, felted chaff and red grain (var. *Hostianum* Clem. Class XXIII); a fully bearded wheat with red, smooth chaff and white grain (var. *erythroleucon* Keke. Class XXXVII), and a similar wheat with red grain (var. *ferrugineum* Al. Class XXXV).

18. *Sára*. This is grown on *khushkába* land only and is used by the poorer people. It is the fully bearded wheat with smooth chaff, red grain and weak, pink straw (var. *erythrospermum* Keke. Class XLIV), which forms one of the constituents of both *spín* and *kamar*. There were also present as impurities in small quantity a similar wheat with white grain (var. *graecum* Keke. Class XLV); a bearded wheat with smooth, red glumes and red grain (var. *ferrugineum* Al. Class XXXIII), and a fully bearded wheat with felted glumes and round, red grain (var. *Hostianum* Clem. Class XXIII).

A sample of wheat labelled *Madar khushkába* was received from an unknown district. This resembled the *spín* wheat of Pishín so closely that it is probable it came from the Quetta-Pishín District.

19. *Madar khushkába*. Three-quarters of the sample consisted of *spín* wheat (var. *meridionale* Keke. Class XXVIII), and there were present in fair quantity a somewhat similar wheat but fully bearded and without rounded glumes (var. *meridionale* Keke. Class XXVI) and a fully bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Keke. Class XLII). There were also present in small quantity a fully bearded wheat with smooth, red chaff and white grain (var. *erythroleucon* Keke. Class XXXVIII); a fully bearded wheat with smooth, white chaff and white

grain (var. *graecum* Kcke. Class XLV), and a fully bearded wheat with red chaff and white grain (var. *ferrugineum* Al. Class XXXV).

LORALAI.

Loralai is a crescent-shaped District bounded on the north by Zhob, on the west by Sibi, and on the east by Déra Ghází Khán and Déra Ismáíl Khán. The District has an area of 7,999 square miles. It is mountainous with long, narrow valleys between the mountain ranges. The chief valleys are the Bori valley on the north which runs east and west with a length of 80 miles and a breadth of only 8 miles, the Sahra which lies in the north-east, the Bárkhán valley in the south-east and the Karcha valley between the Bárkhán valley and Déra Ghází Khán. In the south-western and central portions of the District, lie a series of plains of which the most important is Thal Chotiáli which is so level and flat that it is said to have the appearance of an inland sea.

The climate varies with the altitude. In the west, the summer is cool and the winter intensely cold, while in the south and east the heat in summer is great and the temperature generally is more uniform.

There is no monsoon and the rainfall is small, 8·21 inches at Loralai and 6·75 at Duki, but in contrast with the greater part of Baluchistán the greatest rainfall occurs in the summer, except on the west.

As in Zhob, there are many rivers of which the Anambár and its tributaries are the largest. Many of the streams are used for irrigation. Springs and *kárézes* are also common, the former occur mostly in Sanjáwi *tahsíl*, the latter in Bori. Dry crop cultivation is carried on both by flood irrigation in embanked fields and on rainfall only. The most important flood streams are the Anambár and Thal streams in the Duki *tahsíl.*

The following estimate was made in 1904-05 of the area under these various forms of irrigation :—

	Percentage of cultivated area				
	Bori	Sanjáwi	Duki	Músa Khél	Bárkhán
Permanent irrigation	75	29	45	35	11
Flood irrigation	...	70	55	65	79
Pure rain cultivation	25	1	...	...	10

Wheat is the most important crop in the District ; in Sanjáwi 2,230 acres out of 4,115 acres cultivated were in wheat, in Bori 11,003 acres out of 15,434,

Two methods of cultivating wheat on irrigated land are practised. In the first case, the land is ploughed during the spring and summer after rain, the land is manured in October, and the seed sown broadcast in dry land, which is then ploughed, levelled and irrigated. In other parts of the District, such as Sanjáwi and Duki, the land is watered before sowing and the seed sown by drill. The land destined for wheat is generally well prepared, as much as ten ploughings being given in the Músa Khél *tahsíl*. The amount of irrigation given depends on the locality. The second watering is given a fortnight after germination. During the two winter months, no irrigation is required except in Bárkhán, the third watering being given about the middle of March. In Sanjáwi, water is required every seven to ten days, in Bori twice a month, and in the rest of the District every fifteen or twenty days. In Bárkhán, wheat is watered throughout the winter twice a month. During the winter, the wheat crop is cropped by goats and sheep. The time of sowing and of harvesting varies in the different *tahsíls*. It is earliest in Sanjáwi and Bárkhán.

In dry crop cultivation, the embanked fields are filled with water, ploughed and smoothed in August and September. In some parts of Músa Khél the land is manured. The seed is generally sown by drill but if moisture is abundant it is sometimes sown broadcast.

Wheat is sometimes affected by cold winds in the spring, by white ants in times of drought, by rust and by the rice-stem caterpillar which attacks the roots if too much flood water is used.

The following is the average outturn of wheat in the District :—

	In maunds per acre				
	Sanjáwi	**Bori**	**Duki**	**Músa Khél**	**Bárkhán**
Irrigated and manured land	23	15·18	23	12	25
Land irrigated but unmanured	20	10·12	20	8	20
Sailába	15	...	18	...	25
Khushkába	14	3 9	15	6	15

The following account of the varieties of wheats grown in the Province is taken from the Loralai *Gazetteer* :—

"Several kinds of wheat are grown in the District, the most common ones being the *spín ghanam* or white, and *sra ghanam* or red wheat ; the former is cultivated in *khushkába* and the latter in irrigated land. Besides these two varieties, two others are known in Músa Khél, the *kundi ghanam* and *málav ghanam*, the seed of the former having been imported from the Dáman in the Déraját. The seed of the *málav ghanam* is said to have been imported

from the Kohát District in the North-West Frontier Province and is cultivated in irrigated lands in the Gargoji, Nath and Ganbar villages of the Drug circle."

Sixteen samples were received from the Loralai District.

Duki tahsíl.

1. *Spín ghanam*, white wheat. Very little of this variety is grown and most of it is sold. It is grown both on irrigated and dry crop land and is said to be more rust-resistant than the red wheat. It is a bearded wheat with weak straw, smooth, white chaff and white grain (var. *graecum* Kcke. Class XLV). About half the sample consisted of a similar wheat with red grain (var. *erythrospermum* Kcke. Class XLI).

2. *Sára ghanam*. This is the main variety of the *tahsíl*. It is very liable to rust. It is a bearded wheat with smooth, light red chaff and red grain (var. *ferrugineum* Al. Class XXXII). There was also present a large amount of a similar wheat with a white grain (var. *erythroleucon* Kcke. Class XXXVI); and a small amount of a bearded wheat with red, felted chaff and white grain (var. *turcicum* Kcke. Class XV).

3. *Wadának*. This wheat was introduced from the Punjab and was only grown on a small scale as an experiment. It is the ordinary *Wadának* of the Punjab (Punjab Type 1), a macaroni wheat with black awns, white, felted glumes and white grain (var. *melanopus* Al. Class V).

Sanjáwi tahsíl.

4. *Spín ghanam*, white wheat. About one-third of the wheat cultivated belongs to this variety. It is grown both on irrigated and unirrigated land. It is a strong-strawed, fully bearded wheat with smooth, bright red chaff and white grain (var. *erythroleucon* Kcke. Class XXXVI). There was also present a large quantity of a similar wheat with red grain (var. *ferrugineum* Al. Class XXXII), a fair quantity of a bearded wheat with short, square ears, red, densely felted chaff and white grain (var. *turcicum* Kcke. Class XV) and a very small quantity of a similar wheat with red grain (var. *barbarossa* Al. Class XIII).

5. *Sára ghanam*, red wheat. This is the chief wheat of the tract and is grown on all kinds of land. It is a fully bearded wheat with thin ears, weak straw, smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLI). There was also present in large quantity a similar wheat with stronger straw and white grain (var. *graecum* Kcke. Class XLV), in smaller quantity a bearded wheat with white, densely felted chaff and red grain

(var. *Hostianum* Clem. Class XXI) and a similar wheat with red grain (var. *meridionale* Kcke. Class XXVI).

Bori tahsíl.

6. *Laghar or spín ghanam.* This variety is only cultivated to a small extent. The ears are lax with very rounded glumes and short awns, often black. The chaff is densely felted and white and the grain is white (var. *meridionale* Kcke. Class XXX). There were also present a bearded wheat with white, felted chaff with red grain (var. *fuliginosum* Al. Class XIX); a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLI) and a bearded wheat with smooth, red chaff and white grain (var. *erythroleucon* Kcke. Class XXXVIII).

7. *Spín ghanam.* About two-thirds of the area in wheat is under this variety. It is very rust-liable and is grown both on irrigated and unirrigated land. The ears are short, bearded with black awns: the glumes are densely felted, dark red and sometimes blackened. The grain is white (var. *turcicum* Kcke. Class XV). There was also present in very small quantity a similar wheat with light red grain (var. *barbarossa* Al. Class XIII). In addition, two other wheats occurred in fair quantity: a bearded wheat with smooth, light red chaff and white grain (var. *erythroleucon* Kcke. Class XXXVIII) and a similar wheat with red grain (var. *ferrugineum* Al. Class XXXII).

8. *Sára ghanam.* This variety covers about one-third of the area under wheat. It is more rust-resistant than *spín ghanam* but less so than *laghar*. The sample was a very mixed one. The largest portion consisted of a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLI). There were also present in fair quantity a wheat with short awns, rounded glumes, white, felted chaff and red grain (var. *fuliginosum* Al. Class XVIII); a bearded wheat with smooth, white chaff and white grain (var. *graecum* Kcke. Class XLV); a bearded wheat with smooth, white chaff, rounded glumes and red grain (var. *erythrospermum* Kcke. Class XLII) and in small quantity: a bearded wheat with smooth, red chaff and red grain (var. *ferrugineum* Al. Class XXXII); a similar wheat with dark red chaff and white grain (var. *erythroleucon* Kcke. Class XXXVIII); a bearded wheat with black awns, densely felted, white chaff and white grain (var. *meridionale* Kcke. Class XXVI); a similar wheat with red grain (var. *fuliginosum* Al. Class XX) and a slightly bearded wheat with felted, white chaff, rounded glumes and white grain (var. *meridionale* Kcke. Class XXX).

Bárkhán tahsíl.

9. *Lakhi.* This is the prevailing wheat in this *tahsíl.* It is grown on both unirrigated and irrigated lands and is somewhat rust-liable. The ears are bearded, the chaff smooth and white and the grain red (var. *erythrospermum* Kcke. Class XLI). There were also present as impurities in small quantities a similar wheat with white grain (var. *graecum* Kcke. Class XLV); a bearded wheat with square ears, densely felted, white chaff and red grain (var. *Hostianum* Clem. Class XXI); a bearded wheat with smooth, red chaff and white grain (var. *erythroleucon* Kcke. Class XXXVIII) and a similar wheat with red grain (var. *ferrugineum* Al. Class XXXII).

10. *Dholi.* This variety is not much cultivated but can be grown on both irrigated and unirrigated land. It is a bearded wheat with smooth, white chaff, white grain and rather weak straw (var. *graecum* Kcke. Class XLV). There were no admixtures.

11. *Rodi.*[1] Unlike the first two varieties *Rodi* can only be grown on irrigated land. It is sparingly cultivated. The ears are bearded, the chaff smooth and brownish red and the grain white (var. *erythroleucon* Kcke. Class XXXVIII). There were also present as impurities a similar wheat with red grain (var. *ferrugineum* Al. Class XXXII) and a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLI).

Músa Khél tahsíl.

12. *Kundai.* This variety is grown on light, unirrigated land. It is, however, only cultivated to a small extent. It is a beardless wheat, with dense, club-topped ears, smooth, white chaff and white grain (var. *albidum* Al. Class LXIV). Only one impurity was present a similar wheat with red grain (var. *alborubrum* Kcke. Class LXI).

13. *Urbsen.* Like *Kundai*, this variety is only grown on unirrigated land but the cultivation is general. The ears are bearded with smooth, red chaff and white grain (var. *erythroleucon* Kcke. Class XXXVIII). There were also present a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLII): a bearded wheat with white, felted glumes and red grain (var. *fuliginosum* Al. Class XX); a beardless wheat with smooth, white glumes and red grain (var. *alborubrum* Kcke. Class LXI).

14. *Maláo ghozhiza.* This is a macaroni wheat and is always grown on irrigated land as it requires a plentiful supply of water. The awns

[1] *Rodi* means a perennial river.

are black, the chaff white and densely felted, and the grain white (var. *melanopus* Al.).

15. *Zizha.* This wheat is said to be only sparingly grown and always on irrigated land. The ears are bearded with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLI). There were also present as admixtures a similar wheat with white grain (var. *graecum* Kcke. Class XLV) and a bearded wheat with densely felted, white chaff and red grain (var. *Hostianum* Clem. Class XXI).

ZHOB.

The Zhob District lies in the north-eastern corner of Baluchistán. The greatest length is from east to west (160 miles) and the total area is 9,626 square miles. The greater part of the District is covered with mountain ranges intersected by valleys. In the south lies the great valley of the Zhob, an immense stretch of alluvial plain and in the north lies the valley of the Kundar and its tributaries. There are also numerous smaller valleys.

The climate varies with the altitude. In Upper Zhob and in the highlands generally, the summer is cool and the winter cold, while in Lower Zhob the summer is unpleasantly hot. The rainfall varies in different parts of the District, ranging from 10 inches in Fort Sandeman to about 4 inches in Kila Saifulla and 5 inches at Hindubágh. As in most other parts of Baluchistán, the largest rainfall occurs in the winter months especially in March. Strong winds are common but their direction varies with the season.

There are a very large number of rivers in the District, both perennial rivers and hill torrents. Most of the rivers run from west to east. The two most important are the Zhob and the Kundar with their tributaries. The water in the upper part of the Zhob river cannot be used for irrigation on account of the high banks but lower down dams are thrown across the stream and the water is taken off in open channels for irrigation purposes. This is the method adopted to raise the water in all the permanent streams and in some cases the water is raised to great heights on to terraced fields.

The following estimate of the irrigation facilities and the area watered by them was made in 1904-05:—

	Hindubágh		Kila Saifulla		Fort Sandeman
	Number	*Area*	*Number*	*Area*	*Number*
Streams	5	9,259	10	671	11
Springs	279	2,755	52	948	106
Kárézes	71	5,887	52	19,915	...
Khushkába	...	525	...	199	...

The largest amount of dry crop cultivation is situated in the Kila Saifulla *tahsíl*, the area in the Fort Sandeman *tahsíl* being comparatively small.

Wheat is the most important crop in the District and in the Kila Saifulla *tahsíl* four-fifths of the cultivated area (10,000 acres) was under wheat. The land is ploughed in the spring and watered in September. The seed is sown broadcast and the land is then ploughed. In some parts it is levelled, in others no levelling is ordinarily done. In Fort Sandeman where water is scarce, the seed is sown broadcast in dry land which is then ploughed and levelled and watered later. After germination has taken place, the wheat is ordinarily watered forty days after sowing and again after ten or twelve days. No further irrigation is given for about two months on account of the January and February rains. Generally three more waterings, at intervals of fifteen to twenty-five days, are given from March onwards. Wheat is often grazed by animals in February and March.

In dry crop cultivation, the fields are embanked and filled during the summer with rain or flood water if possible. They are then ploughed in August or September and left smooth. Sowing may be carried out at any time from October to the end of March depending on the rainfall. In Hindubágh, the seed is sown broadcast and is then ploughed in and covered. In other parts, the land may be first prepared and then sown by drill.

Manure is generally used in irrigated land except in very fertile land or in places where land is left fallow for long periods, owing to the scarcity of the water-supply. Dry crop lands are cultivated every year while some of the irrigated land is left fallow for several years. Only 271 acres out of 39,527 acres were cropped twice a year and some land was only sown once in ten years.

The following are the average yields of wheat in maunds per acre obtained from crop-cutting experiments :—

	Fort Sandeman	Kila Saifulla	Hindubágh
Irrigated and manured	12	16	17·3
,, but unmanured ...	8	9·2	15·4
Unirrigated	6·5	...	...

The varieties of wheat grown in the District are described in the *Gazetteer* as follows :—

"Two varieties of wheat are grown in the Hindubágh *tahsíl*, viz., the *sára ghanam* or winter wheat, which is white, and *tauda ghanam* or summer wheat, which is red and has a smaller grain. In Kila Saifulla two varieties are found–*sra* or *red*, and *spín* or white wheat ; the red variety is largely

cultivated and is also common to Fort Sandeman, where three more varieties are recognised—*tor ghanam*, *orbasín ghanám* and *ghat ghanam*, all being indigenous to the country. The *tor ghanam* has a longish hard grain, yellowish in colour, the ear being dark, whence the name. The *orbasín ghanam* is reddish in colour, the grain is small and soft and the ear long but thin and yellow in colour. *Ghat ghanam* has a beardless ear which is thick but small, the grain being yellowish. All are cultivated equally in different parts of the *tahsíl* and the sowing operations extend from October to end of January."

The following samples of wheat were received from this District :—

Kila Saifulla tahsíl, Upper Zhob.

1. *Spín ghanam.* This variety is grown both on irrigated and unirrigated land. It is considered to require less water than *sra ghanam.*

Two samples of *spín* were sent from this *tahsíl.* The first labelled *Spín kosham* consisted of a wheat with very short, black awns, greyish white, densely felted, rounded glumes, and white grain (var. *meridionale* Kcke. Class XXX). No impurities were present.

The other sample was very mixed but the two main constituents were : a bearded wheat with densely felted, light red chaff and awns and white grain (var. *turcicum* Kcke. Class XV) and a fully bearded wheat with smooth, light red chaff and awns and red grain (var. *ferrugineum* Al. Class XXXII). There were also present as impurities a bearded wheat with felted, bright red chaff and pale red grain (var. *barbarossa* Al. Class XIII) and a bearded wheat with smooth, red chaff and white grain (var. *erythroleucon* Kcke. Class XXXVIII).

2. *Sra ghanam.* This wheat is grown on both irrigated and unirrigated land. It is a bearded wheat with smooth, white chaff, very weak straw, and red grain (var. *erythrospermum* Kcke. Class XLI). There was only one impurity, a similar wheat with white grain (var. *graecum* Kcke. Class XLV).

3. *Mecca Muazzama.* This variety is said to have been imported from Mecca by *Hajis* and is considered to be most sacred. It cannot be sown without performing the ceremony of ablution necessary before offering prayers. It is cultivated to an insignificant extent to neutralize the effect of evil eye in a field. It is a macaroni wheat with an extraordinarily long grain even for a macaroni and with two peculiar ridges on the outer glume. The awns are black, the chaff white and felted and the grain white (var. *melanopus* Al. Class IV).

Hindubágh tahsíl, Upper Zhob.

4. *Spín ghanam.* This variety is also cultivated on irrigated land. The sample consisted mainly of a mixture of wheats all with white, densely felted and very rounded glumes, white grain and strong straw but with very varying amounts of bearding (var. *erythroleucon* Kcke. Classes XXVIII & XXIX). Some were almost fully bearded, others almost beardless. From the appearance of the sample it would seem as if a good deal of natural crossing had taken place. There was also present, as an impurity in small quantity, a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XL).

5. *Sra ghanam.* This was a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLII). There were also present a bearded wheat with white, densely felted chaff, rounded glumes, poor straw and red grain (var. *Hostianum* Clem. Class XXIV); a similar wheat with white grain (var. *meridionale* Kcke. Class XXVI) and a bearded wheat with smooth, white chaff and white grain (var. *graecum* Kcke. Class XLV).

Kákar Khorásán sub-tahsíl, Lower Zhob.

6. *Sur ghanam* (red wheat). This is the variety most commonly grown in the locality. It is cultivated both on dry and irrigated land and is said to be rust-liable. One sample of this variety was sent. The ears were thin and badly matured. It was a fully bearded wheat, with smooth, red chaff and dark red grain (var. *ferrugineum* Al. Class XXXIII). There was a small quantity of a similar wheat with white grain present as an impurity (var. *erythroleucon* Kcke. Class XXXVII).

7. *Spín ghanam* (white wheat). Samples of this wheat grown in different villages were sent. Three of them consisted of a fully bearded wheat with smooth, white chaff, weak straw and white grain (var. *graecum* Kcke. Class XLV). A similar wheat with red grain was present as an impurity (var. *erythrospermum* Kcke. Class XL). This was the only impurity in the first sample, in the second there was also present a bearded wheat with strong straw, white, felted glumes and red grain (var. *fuliginosum* Al. Class XVIII), and in the third a fully bearded wheat with white felted glumes and white grain (var. *meridionale* Kcke. Class XXVI). The fourth sample was a red wheat with long, lax, fully bearded ears, smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XL).

Fort Sandeman tahsíl, Lower Zhob.

Four samples were sent from this *tahsíl.*

8. *Orbasín ghanam.* This wheat was somewhat difficult to classify. The grain was soft and large and resembled that of a rivet wheat but in other particulars the ears were those of a macaroni wheat. This wheat has short ears, long red awns and smooth, red chaff; the grain is white and soft and the straw strong with a pink tinge (var. *hordeiforme* Host. Class VIII). One ear was found which looked like a natural cross between this wheat and a common wheat. It was dense and flat and only half bearded.

9. *Tor ghanam.* This is also a macaroni wheat but with no peculiarities. It is a black awned wheat, the chaff white and felted with much blackening and the grain white, hard and long (var. *melanopus* Al. Class VI). There were present as impurities some *orbasín* wheat; a common wheat with black awns, white, felted chaff and red grain (var. *fuliginosum* Al. Class XX) and a common wheat fully bearded with smooth, white chaff and red grain (var. *ferrugineum* Al. Class XXXIII).

10. *Ghat ghanam.* This resembles the wheat *spín* from Pishín and other localities. It is almost beardless, with white, felted chaff, rounded glumes and white grain (var. *meridionale* Kcke. Class XXX). There were present as impurities, in large quantity *sra ghanam*, and in small quantity a slightly bearded wheat with white, felted glumes and red grain (var. *Hostianum* Clem. Class XXIV), a practically beardless wheat with small tips, rounded glumes, smooth, white chaff and white grain (var. *albidum* Al. Class LXII), and a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLII).

11. *Sra ghanam.* This is a common wheat with medium, fully bearded ears, white awns and smooth, white chaff. The grain is small and red and the straw pink turning black on ripening and weak (var. *erythrospermum* Kcke. Class XLII). There were also present as impurities some *Ghat ghanam;* a bearded wheat with black awns, white, felted chaff and red grain (var. *fuliginosum* Al. Class XX) and a macaroni wheat with red awns, smooth, red chaff and red grain (var. *murciense* Kcke. Class VII).

CHAGAI.

The Chágai District (18,892 square miles in area) lies immediately south of the Baloch-Afghan boundary. The District is divided into three parts, the Nushki *tahsíl* on the east, the Chágai *sub-tahsíl* in the centre and the Western

Sanjráni Tract on the west. There is very little cultivation in the District, much of the country being sandy desert and much of it only suitable for grazing. The cultivation is mainly confined to the level plain of alluvial soil lying between Nushki and Chágai on which most of the rivers are situated.

There is only one river with a perennial flow of water, the Khaibar or Jo-i-Nushki which irrigates the land in the neighbourhood of Nushki (about 2,000 acres in 1905). There are in addition numerous hill torrents which supply flood water for the dry crop cultivation. These torrents are held up and directed into specially constructed channels by embankments which are generally made and repaired by a whole village or tribe who divide among themselves the water so obtained. There are a certain number of *kárézes* both in Nushki and Chágai but most of them are small and insignificant. The five largest in Nushki irrigate about 600 acres (1905) while in Chágai the largest *kárez* only irrigates 22 acres.

The average rainfall at Nushki is 4·5 inches derived from the winter storms which come from Persia but these vary from year to year. Usually no snow falls on the plains. The summer is very long, lasting from April to October and the temperature in the plains is high.

The soil in the cultivated tracts is alluvial and very fertile but, owing to the limited amount of water, nine-tenths of the cultivation is dry crop cultivation dependent on the flood water brought down by the hill torrents in winter and early spring. The best *khushkába* cultivation is found on the *Dák*, *i.e.*, the land lying along the course of the Lora. Other dry crop lands lie round Mal and Chágai. Most of the irrigated land lies round Nushki and Baghat and is watered from the Kaisar river.

The area under wheat is not known accurately but wheat represents about 95 per cent. of the total produce of the District. Wheat is always sown in fallow land and the land after a wheat crop is always left fallow for a year or two. In September the land is irrigated, ploughed and levelled, the seed being sown by drill at the beginning of October. The first irrigation is given when the wheat is 6 inches high and the crop is either grazed by sheep or cut for fodder in January. The second watering is given twenty days later, the third when the ears are formed and the fourth when the grain has set. The wheat is ripe in May or June. On unirrigated lands, the time of sowing depends on the winter rains and may take place at any time up to February. The seed is also sometimes sown in the dry land before the rains.

The average yield of wheat per acre in the Nushki *tahsíl* in 1905 was $6\frac{1}{2}$ maunds, the highest yield being 8 maunds per acre on irrigated land. In Chágai, the cultivators say the outturn of wheat should be ten times the seed sown.

Six samples were received from the Chágai District.

Nushki tahsíl.

1. *Dahyak.* This is the wheat which the people prefer for food and which is most commonly grown. It is sown in both irrigated and unirrigated land. The bulk of the sample consisted of a common bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLI). There were also present as admixtures a wheat similar to the above but with white grain (var. *graecum* Class XLV); a bearded wheat with smooth, red chaff and red grain (var. *ferrugineum* Al. Class XXXII); a bearded wheat with smooth, red chaff and white grain (var. *erythroleucon* Kcke. Class XXXVIII) and a bearded wheat with white, felted chaff and red grain (var. *Hostianum* Clem. Class XXI).

2. *Turki.* This wheat is not very extensively grown and is only sown in irrigated land. The sample consisted of a mixture in equal parts of a partly bearded wheat with very rounded, white, densely felted glumes and white grain (var. *meridionale* Kcke. Class XXIX) and of a beardless wheat with smooth, white chaff and white grain (var. *albidum* Al. Class LIII).

3. *White wheat from Nushki village.* Three-quarters of the sample consisted of a wheat with very short awns, rounded, white, felted glumes and white grain (var. *meridionale* Kcke. Class XXIX). There were also present as admixtures in large quantity a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLI) and in small quantity a bearded wheat with felted, white chaff and red grain (var. *Hostianum* Clem. Class XXIV).

Chágai sub-tahsíl.

4. *Dahyak.* This was similar to the *Dayhak* wheat received from Nushki but there were no impurities.

5. *Turki.* This variety is only grown on irrigated land. The bulk of the sample consisted of a mixture of the partly bearded wheat with rounded, white, felted glumes and white grain (var. *meridionale* Kcke. Class XXIX) found in *Turki* from Nushki and of a somewhat similar wheat but fully bearded and with sharply keeled glumes (var. *meridionale* Kcke. Class XXVI). There

were also present as admixtures a bearded wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLI) ; a fully bearded wheat, with white felted chaff and red grain (var. *Hostianum* Clem. Class XXI) ; a similar wheat but very shortly awned and with short, rounded glumes (var. *meridionale* Kcke. Class XXIV) and a bearded wheat with red, densely felted chaff and white grain (var. *turcicum* Kcke. Class XV).

6. *Siah das.* This wheat, as the name implies, has much black colour on the awns and glumes. It is said to be grown mostly on irrigated land. The bulk of the sample consisted of a bearded wheat with smooth, red chaff with much blackening on the awns and glumes and red grain (var. *cæsium* Al. Class XXXI). There were also present as impurities in very small quantity a similar wheat with white grain, a bearded wheat with white chaff and red grain (var. *erythrospermum* Kcke. Class XLI) and a bearded wheat with red, felted glumes much blackened and red grain (var. *fuliginosum* Al. Class XIX).

KACHHI, KALAT.

Kachhi, the most easterly portion of the Khán of Kalát's dominions, adjoins the Nasírábád and Sibi *tahsíls* of the Sibi District and resembles these in many particulars. It consists of a flat, triangular plain surrounded by mountains. The altitude is nowhere above 500 feet, but there is an almost imperceptible slope from north to south.

The climate is like northern Sind excessively hot in summer and very dry. Unlike most parts of Baluchistán, there are only two seasons, summer and winter, and the former is much the longest. The rainfall is very small, about 3 inches.

The soil is very fertile if water is available but the irrigation water is not nearly sufficient for the whole area and there are large stretches of desert with no vegetation. There is a fringe of land under the hills which receives permanent irrigation but most of the cultivation is carried out on flood water from the rivers. There are numerous rivers and hill torrents in Kachhi of which the Nári, the Bolán, the Sukléji, the Múla, the Lahri and the Chattar are the most important. These streams are held up by enormous dams and the water is deflected into numerous side channels both natural and artificial. Some of the dams are very large but they are all of earth or sand and brushwood and break under sudden floods. They are made and repaired on a communal basis.

There is much waste of water due to want of system and organization and in especial the frequent breaking of these huge earthen dams leads to deflection and waste of water. In a very few places, notably on the Bolán, Persian wheels are used to lift the water. Apart from this flood irrigation, there seem practically no other sources of water. Only seventeen *kárézes* and nine springs are in use and there are hardly any wells.

Wheat is grown to the greatest extent on the west side of Kachhi as permanent irrigation exists there. It can only be grown on flood areas if floods have occurred in August and September.

Irrigated land is always fallowed for two years, if wheat is grown. It is seldom manured but sometimes bat's dung or pigeon's dung is spread over the field when the crop is a foot high. The land is watered and ploughed in October and the seed is sown broadcast. On irrigated land, the beam is never used. The second watering takes place when the wheat is three inches high and it is then watered about every fortnight, the length of the interval depending on the water-retaining power of the soil. Harvest takes place in April.

In dry crop cultivation, the land is ploughed and smoothed after the summer floods and sown with the drill in October.

On both irrigated and unirrigated lands barley is sometimes sown with the wheat.

Six samples were received from Kachhi, four from the Dhádar *tahsíl* and two from the Gandáva *tahsíl*.

Dhádar, Kachhi.

1. *Reli.* This wheat is said to have been introduced by the British. It is much liked and is now extensively grown. The beardless ears are very large and bold with fan-shaped apices. The chaff is white and felted but the felting seems to vary in density. The grain is white and hard and the very strong and stout straw is pink in colour turning black on ripening (var. *leucospermum* Kcke. Class LIII). A similar wheat with smooth chaff was present (var. *albidum* Al. Class LXIII). The presence of these smooth ears combined with the variation in density of the felted ears makes it appear probable that in this sample we are dealing with the progeny of some natural cross between a smooth and a felted wheat.

2. *Baj.* This is said to be a red wheat and to be valued less highly than *Reli.* Seven-eighths of the sample however consisted of a wheat

with white grain. The ears were beardless with small tips and the glumes red and felted (var. *Delfii* Kcke. Class XLVIII). One-eighth consisted of a similar wheat with red grain (var. *pyrothrix* Al. Class XLVI). There was also present in small quantity a beardless wheat with smooth, light red chaff and white grain (var. *alborubrum* Kcke. Class LVIII).

3. *Wáru white wheat.* As this variety is considered of poor quality, it is termed *wáru* which means inferior. It is generally grown on land which is not under permanent irrigation. Two-thirds of the sample was composed of a bearded wheat with slender heads, smooth, white glumes, red grain and weak straw (var. *erythrospermum* Kcke. Class XLII) and one-third consisted of a similar wheat with felted chaff (var. *fuliginosum* Al. Class XIX). There was also present in very small quantity a bearded wheat with smooth, white glumes and white grain (var. *graecum* Kcke. Class XLV).

4. *Wáru red wheat.* This is also grown in unirrigated land and is of poor quality. This variety was a somewhat curious one. The ear shape is that of a common wheat but the glumes are sharply keeled to the base like those of a macaroni. The straw is almost solid but is stout not thin as in a macaroni wheat. The grain is large and like that of a rivet in shape. The ears are bearded, the glumes smooth red and the grain white (var. *erythroleucon* Kcke. Class XXXVIII). Only one impurity was present, a somewhat similar wheat with red grain (var. *ferrugineum* Al. Class XXXII).

Gandáva tahsíl.

5. *Thori.* This was a very mixed sample, containing nine different wheats. Although *thori*, meaning bald, generally denotes a beardless wheat the main constituent was a bearded wheat with slender ears, smooth, white glumes, red grain and weak, pink straw which turns black on ripening (var. *erythrospermum* Kcke. Class XLII). There were also present in fair quantity a beardless wheat with short tips, white, densely felted glumes and white grain (var. *leucospermum* Al. Class LV); a similar wheat but with quite beardless ears and red grain (var. *velutinum* Schübl. Class LI), a beardless wheat with smooth, white chaff, red grain and pink straw which turns black on ripening (var. *lutescens* Al. Class LXI). There were present in very small quantity a beardless wheat with white chaff and white grain (var. *albidum* Al. Class LXII); a beardless wheat with smooth, red chaff and red grain (var. *milturum* Al. Class LVI); a beardless wheat with red, felted chaff and red grain (var. *pyrothrix* Al. Class XLVI); a bearded wheat

with black awns, greyish white, densely felted glumes and red grain (var. *fuliginosum* Al. Class XX), and a dwarf wheat with smooth, white chaff, white grain and pink straw (var. *Humboldti* Kcke. Class X).

6. *Wáru wheat*. This sample was also very mixed, eight different wheats being found in it. The main constituent was a beardless wheat with small tips, light red, felted glumes, white grain and good straw (var. *Delfii* Kcke. Class XLVIII). There were also present as impurities a similar wheat with red grain (var. *pyrothrix* Al. Class XLVI); a beardless wheat with short tips, smooth, light red chaff and red grain (var. *milturum* Al. Class LVI); a similar wheat with smooth, white chaff and red grain (var. *erythrospermum* Kcke. Class XLII); a beardless wheat with smooth, red chaff and white grain (var. *alborubrum* Kcke. Class LVIII); a beardless wheat with dense ears with fan-shaped apices, white, felted glumes, white grain and very strong straw (var. *leucospermum* Kcke. Class LIII), and the same dwarf wheat as in the sample of *Thori* (var. *Humboldti* Kcke. Class X).

MAKRAN, KALAT.

This is one of the maritime divisions of the Kalát State. The coast is practically a desert owing to the nature of the soil, which is impregnated with salt, and the scanty rainfall. From the level clay plains of the coast rise table hills and behind these lie ranges of high mountains, parallel with the coast and intersected by narrow valleys, in which the cultivation is carried on.

The climate varies greatly. The central inland portion is extremely hot and dry while the higher valleys such as Panjgúr are fairly temperate. There are three seasons, spring from March to May, summer from June to October and winter from November to February. The seasons in Panjgúr are about a month later than in Kéch. The rainfall is very uncertain but never exceeds a few inches. None may be received for two or three years. The rain generally comes in the form of storms between November and March and in July and August. On the west, the winter rainfall is the greatest, on the east the summer rainfall. As most of the rain falls in the hills sudden floods, which do great harm to cultivation, are common on the plains.

There are several rivers in Makrán of which the Dhast, the Rakhshán, the Tank and their affluents are the most important. From most of these rivers irrigation is carried out by means of *kaur-jos* or open channels leading from pools. In almost all the rivers, the river bed expands at short intervals

into shallow pools, the intervening stream flowing over a pebbly bed. These pools are often increased or deepened by artificial means and an open channel is constructed to carry the water on to the land. The construction and cleaning of these channels is done by co-operation between the members of a village or a family just as in the case of a *káréz*. A considerable area is irrigated in this manner. There is a tradition that large dams used to exist at certain places but at present the number of dams is insignificant.

A large area is under *káréz* irrigation, and the remains of old *kárézes* show that this area used to be considerably larger.

A certain number of wells are also used for cultivation. Two systems of water lift are in use, the ordinary Indian bucket lift or *dhénkoli* and the *galjali* system from Sind. The leather bucket in this case has an elongated tube at the bottom and can be opened automatically by a rope attached to the yoke.

Very little wheat is grown, the local requirements being met by importation from Karáchi and other places. It is generally grown on irrigated land except in Panjgúr where the irrigated land is so closely planted with dates that the wheat will not grow. The crop is however grown on unirrigated land in Panjgúr. Practically all the wheat grown on irrigated land is grown under dates (they are not so closely planted as in Panjgúr) and the yield is therefore poor.

For irrigated cultivation, the land is ploughed as soon as the last wheat crop is removed. It is then ploughed again after the date harvest, and after the 20th of October the land is watered and sown broadcast. The field is then ploughed and levelled with the beam. This is the best time to sow but sowings can be extended to December. The first watering is given when the plant has tillered (termed *chuk-o-mát* or mother and sons) about a month after sowing. The second watering is given about a fortnight later and the third two months after sowing. The wheat is then grazed. Harvest takes place in March or April.

On unirrigated land the wheat is sown with the drill. The best dry crop lands are the embanked fields of the Rakshán river. The land is generally ploughed and levelled after the summer rainfall and sown in October but in some cases the water-holding capacity of the soil is so great that even when irrigated in February, if ploughed and levelled at the time, it can be sown in October or November. To ensure a good crop, rain is necessary during the first sixty days.

Wheat in Makrán especially in Kolwa is liable to damage by the rice-stem fly. The local name of this is *dard* or pain because the stalks collapse as if in pain. The remedy adopted by the people is the application to the field of the dried blood of goats or sheep which have been killed on the *Id-uz-zuha*.

The following is the description of the varieties of wheat given in the Makrán *Gazetteer* :—

"The generic term for wheat is *galla* ; and its varieties are known as *mátoshag* and *chirok*, which are most extensively cultivated in the Kéch valley and *panáro* or *pazhmak*, which are commonest in Buléda, Zámurán and Panjgúr ; another kind is *dahak* which is grown in Panjgúr. The colour of both *mátoshag* and *chirok* wheat is red but the latter is somewhat darker than the former. *Mátoshag* is famous for the size of its grain. It is cultivated only on a limited scale, as it is easily affected by *dard*. *Chirok* is considered the variety indigenous to Makrán and the grain is very small except in Panjgúr. It is much appreciated for its flavour and sweetness, and is popular for parching when green (*tápag* and *mushag*). It is very sweet to the taste and in Panjgúr and other localities is sown in equal proportions with other varieties. *Panáro* is the largest wheat grown in the country and is lighter in colour and rounder in shape than the others. Bread made from it, however, is not so sweet as that made from *chirok* nor so nutritious as that made from *dahak*. *Dahak* resembles *chirok* but is larger and yellower in colour. Locally it is considered the equal of Mastung wheat in taste and quality but is believed to be even more nutritious."

Seven samples were received from Makrán.

Panjgúr.

1. *Dahak.* This is the common wheat of Panjgúr. The ears are lax, fully bearded with smooth, white glumes, dark red grain and weak, pink straw (var. *erythrospermum* Kcke. Class XLII). There were also present in small quantity a bearded wheat with smooth, red glumes and red grain (var. *ferrugineum* Al. Class XXXIV), and a bearded wheat with white, slightly rounded, sparsely felted glumes with red grain (var. *Hostianum* Clem. Class XXI).

2. *Shutur dandan.* This variety is said to be not quite so commonly grown as *Dahak* but the sample received was very similar to *Dahak*. The only differences which could be noticed were a weaker straw and a shorter ear in *Shutur dandan*. There was only one impurity, a bearded wheat with smooth

white chaff and white grain (var. *graecum* Kcke. Class XLV). It seems probable that the real *Shutur Dandan* was not sent.

3. *Pindaro.* This is the least cultivated of the three kinds. The sample was a mixture of a macaroni wheat with white awns, smooth, white chaff and white grain (var. *leucomelan* Al. Class IX) and a rivet wheat with short ears, black awns, white, densely felted glumes and white grain (var. *Salomonis* Kcke. Class I). There were also present in small quantity two other macaroni wheats; one with red awns, smooth, red glumes and red grain (var. *murciense* Kcke. Class VII), and one with white awns, white, lightly felted glumes and white grain (var. *melanopus* Al. Class VI).

Kéch.

4. *Chirok.* Sample A grown on irrigated land. This is the common wheat of Kéch. The ears are bearded and very small with black awns and smooth, red, rounded glumes. There is some blackening on the chaff and the red grain is small and rounded (var. *caesium* Al. Class XXXI). This variety resembles very closely some of the wheats of Bihar.[1] These also have small, rounded grain, small heads and much blackening on the chaff. As far as is known, such wheats are found nowhere else in India and it is curious that *Chirok* which is supposed to be the wheat indigenous to Makrán should be almost identical with the wheats of so distant a part of India as Bihar.

Sample B, grown on dry land, resembled the first sample but the heads were bigger and the straw stronger.

5. *Mátoshag.* This wheat is less commonly grown than the *Chirok*. The ears are short, very dense and square. The awns are black and long and the glumes red and densely felted. The grain was red (var. *barbarossa* Al. Class XI).

6. *Koto.* This variety is considered to be a delicacy and is only eaten parched. It is only grown in very small quantities. The ears are beardless with smooth, red glumes. The grain is white and rounded and the straw stout and black when ripe (var. *alborubrum* Kcke. Class LVIII).

A set of samples was received from one of the Districts without any indication of the place of origin. These samples were labelled *Saloman razi*, *Bati razi*, *Kumar*, *Shahderzi* and *Khudadadarzi*.

1. *Saloman razi.* The main constituent of this sample (forming five-sixths of the total) somewhat resembled the *Spín* wheat received from

[1] Howard and Howard, *Wheat in India*, p. 201.

Pishin. The lax ears had short awns, the glumes were rounded, white and felted, the grain white and the straw strong (var. *meridionale* Kcke. Class XXIX).

2. *Khudadadarzi.* Seven-eighths of the sample was the same as sample 1.

3. *Bati razi.* Two-thirds of the sample was identical with the other two.

4. *Kumar.* This was a mixture of the wheat described above and a bearded wheat with smooth, red chaff and red grain (var. *erythrospermum* Kcke. Class XLIII). This wheat was also present in small quantity in samples 1, 2, 3.

5. *Shahderzi.* This was a similar mixture to *Kumar.*

The following wheat was present in all the samples in small quantity : a bearded wheat with white, felted glumes and white grain (var. *meridionale* Kcke. Class XXVI). A similar wheat with red grain (var. *Hostianum* Clem. Class XXIV) was also present in samples 1, 2, 4, and 6. A bearded wheat with smooth, white glumes and white grain (var. *graecum* Kcke. Class XLV) was present in samples 1, 3, 4, 5. Sample 2 which was very mixed contained in addition to the above mentioned impurities a bearded wheat with red, felted glumes and red grain (var. *barbarossa* Al. Class XIII), and a bearded wheat with smooth, red glumes and white grain (var. *erythroleucon* Kcke. Class XXXVIII), while a similar wheat with red grain (var. *ferrugineum* Al. Class XXXIII) was present in sample 1. Samples 3 and 5 also contain a wheat with short awns, white, felted glumes and red grain (var. *Hostianum* Clem. Class XXII).

In the description of the various agricultural processes in vogue in Baluchistán, full use has been made of the information in the Gazetteers of the various Districts.

THE WHEATS AND BARLEYS OF KHORÁSÁN.

I. INTRODUCTION.

In 1910, a report on the agriculture of Khorásán was published by Major Sykes, (now Sir Percy Sykes) Consul-General and Agent of the Government of India in Khorásán. Samples of the wheats were also sent to Pusa for classification.

Khorásán, with an average altitude of 3,000 to 4,000 ft., lies in the north of the Irán plateau which includes the whole of the uplands of Persia and Afghánistán. The climatic conditions resemble those of the higher parts of Baluchistán. The temperature rarely falls below zero in winter and the highest temperature in summer is about 100° with cool nights. Snow falls in December, January and February but the average combined snow and rainfall is only 10·20 inches per annum. In common with Seistán and Baluchistán, Khorásán suffers very much from strong, dry winds, notably the "wind of 120 days." The soil most commonly found is known as *kirmiz* or crimson and is a dark coloured loam.

The following account of the cultivation of wheat is taken from Major Sykes' report :—

"Land destined for wheat or barley has, very frequently, been fallow for as much as five or six years, during which period it has either remained almost bare with a few thorns growing on it : or if naturally comparatively moist, it is covered with liquorice which has a deep root : but which is of no value as a crop, although it is used for binding round a broken limb and as a specific against fever. The first ploughing generally takes place when the land is wet during the spring, and this ploughing is repeated two or three times. In the autumn, the land is levelled and divided into suitably sized plots called *kala* by means of tiny ridges known as *pal.* A *kala* for wheat or barley is from 3 to 5 *zars*[1] wide and from 40 to 50 and sometimes 100 *zars* long. It all, however, depends on the nature of the ground and the volume of the water. After again being watered, the seed is thrown on broadcast. In this connexion, land is generally flooded to a depth of three inches for grain crops : but to

[1] 1 *zar*=40·95 inches.

about half this depth for melons and cucumbers. Finally, the seed is covered by means of a log harrow, *mala*, which is drawn over it with a man sitting on it. Sowing, I would mention, goes on all through the winter except when the ground is ice-bound or covered with snow, the custom being to sow 2 *kharwars*[1] at the main autumn sowings and 1 *kharwar* in the spring and at odd times.

In the large majority of cases, there is no manure used and the land is not given the preliminary ploughing. Land used for rain crops is never manured, but the seed is scattered broadcast after rain, the land is ploughed, levelled by the board harrow and left to chance. Occasionally rain crop land is given a preliminary ploughing.

Weeding is not done in the case of irrigated wheat and barley crops, but once with rain crops. Vegetables and opium are carefully weeded. Wheat and barley are well up before the winter sets in and do not appear to suffer from the frost although occasional snowfalls are considered to be desirable. In the early spring, when the crops are about eight inches up, they are either cut down or grazed. Apart from the value of the fodder, this is thought to strengthen the crop.

A large crop depends mainly on the rainfall in March, April and May, and the cultivator only waters his wheat and barley three times after 21st March, if the rainfall be good. When the ear begins to form, no more water is given and late rains, *i.e.*, after the end of May cause rust. It, however, partly depends on the nature of the soil. In some cases, water is given in the interval commencing from the formation of the ear and the ripening of it. No water, however, is given after the kernel has been formed. A cultivator can see by the colour of the leaf if water is required. If the leaf assumes a dark hue he knows that the field is thirsty and requires water, but if he sees the leaf inclined to be yellow, he stops the water till the leaf has assumed its natural colour. By the middle of June around Meshed, the barley crop is ripe and the wheat follows about a fortnight later. Neither rain nor frost is to be feared at this season, so operations are conducted in a leisurely fashion.

The actual reaping is done with a somewhat blunt sickle and the bundles are not tied up but thrown together. Later, they are collected into a round rick near the threshing-floor.

The threshing is carried out by means of unmuzzled oxen which are yoked to a wooden instrument termed a *gardu* (roller), on which a man sits. As the

[1] 1 *Kharwar*=650 lb.

oxen move round, two wooden wheels furnished with spikes cut up the straw which is much shorter and finer than in England.

Winnowing is carried out by throwing everything into the air by means of a wooden fork termed *charlakh* (four pointed) when the dust and chaff flies away. There is, generally speaking, a steady breeze in the afternoons.

The grain is left in heaps, generally with some private marks on them, until the share of the landlord or the revenue be paid. It is then carried into the granary and thrown in a heap on to a mud floor.

In the hills land which is generally terraced is sometimes cropped every year. Owing to the silt being abundant, this is possible, but land is allowed to be fallow when sufficiently abundant.

Both wheat and barley are grown either as a rain-fed crop, *daima*, or by irrigation, *abi*.

The proportion of these two crops varies enormously according to the amount and seasonableness of the rainfall. In a good year, in the valleys, 30 per cent. of the wheat may be rain-fed : in the hills the percentage rises to 65 per cent. Rain-fed wheat always fetches *toman*[1] 1 to *tomans* 2 per 650 lb. more than irrigated wheat. The reason for this is that one *man* ($6\frac{1}{2}$ lb.) of rain-fed flour makes $1\frac{3}{4}$ *man* of bread, whereas, at most, $1\frac{1}{2}$ *man* is made from the irrigated article. Moreover, the bread made from rain-fed wheat keeps good for three days and is sweeter than the other : but bread baked from the irrigated article can only be eaten fresh.

Abi wheat seed is never used to grow *daima* as it does not turn out well ; *daima* seed can be sown for *abi* with very good results. One *man* of *daima* seed is sown in as much ground as would take three *mans* of *abi* seed. The proportion in the produce is the same. *Daima* produces on an average 30 grains for one grain and *abi* only ten to twenty grains. It is calculated that 360 grains are sown per square metre or *zar*. As Persians say, 'every footprint of a goat should have a grain sown.' Another calculation is that 10 *man* or 65 lb. per acre are sown per *jarib* or acre of stony ground and 13 *man* or $84\frac{1}{2}$ lb. per acre in good soil without stones. There is no difference in the value of the two species of barley. Barley, however, which is sown for a late crop is termed *tursh* or bitter and is not considered fit for anything except for donkeys.

Wheat is of the following varieties :—1. *Daima*–(*a*) *Kalkori*, (*b*) *Kalb Ali Khani*, (*c*) *Safed Khosha*, (*d*) *Surkh Das* ; (*a*) the ear and the grain is red :

[1] 1 *toman*=4 shillings.

there is no beard and the grain is big ; (*b*) ear and beard red, grain also red but inclined to be yellowish, size of grain medium ; (*c*) ear and beard white like paper, the grain is also white ; (*d*) ear and beard and grain red, the grain is small and fine like rice.

2. *Abi*–(*a*) *Kar-i-Safid*, (*b*) *Kar-i-Kirmiz*, (*c*) *Siah Das*, (*d*) *Shutur Dandan* ; (*a*) ear is full and white, with short beard, the grain is white and big ; (*b*) ear is red with short beard, the grain is yellow ; (*c*) ear and beard black, the grain is yellow and very transparent ; (*d*) the ear is between red and yellow in colour, the beard is small and the grain red.

From the milling point of view, the best wheat is *Surkh Das*, both of the *daima* and *abi* classes.

On the uplands of Persia, wheat takes from seven to nine months to mature, but in the hot country only four to four and a half months. These periods approximately correspond with the eight months of England and the four and a half months of India."

II. CLASSIFICATION AND DESCRIPTION OF THE WHEATS.

A. CLASSIFICATION OF THE WHEATS OF KHORÁSÁN.

TRITICUM DURUM DESF. MACARONI WHEATS.

1. Glumes felted.
    - A. Glumes white, awns white, grain white.
      var. *Valenciæ* Koke.
      Khorásán Class I.
    - B. Glumes white, awns black, grain white.
      var. *melanopus* Al.
      Khorásán Class II.

TRITICUM VULGARE VILL. COMMON WHEATS.

I. Ears bearded.

1. Glumes felted.

A. Glumes red.

a. Grain white.

var. *turcicum* Kcke.

Khorásán Class III.

B. Glumes white.

a. Grain red.

var. *Hostianum* Clem.

Khorásán Class IV.

b. Grain white.

var. *meridionale* Kcke.

Khorásán Class V.

2. Glumes smooth.

A. Glumes red.

a. Grain red, awns red.

var. *ferrugineum* Al.

Khorásán Class VI.

b. Grain white.

var. *erythroleucon* Kcke.

Khorásán Class VII. Ears fully bearded, glumes not rounded.

Khorásán Class VIII. Ears only partly bearded, glumes very rounded.

B. Glumes white.

a. Grain red.

var. *erythrospermum* Kcke.

Khorásán Class IX.

b. Grain white.

var. *graecum* Kcke.

Khorásán Class X.

B. DESCRIPTION OF THE WHEATS OF KHORÁSÁN.

TRITICUM DURUM DESF. MACARONI WHEATS.

Ears flat; flowering glumes with long awns, outer glumes sharply keeled to the base; straw stiff and solid; grain long.

var. *Valenciae* Keke.

Khorásán Class I. Ears very long and thin, awns white; chaff felted, white; grain white, long, very thin and translucent.

To this class belongs *Shutur Dandan.* The sample was not well matured and had apparently suffered from shortness of water. A few ears were also found as an impurity in the sample of *Safed Khosha.* This variety is also reported from Valencia in the Russian Province of Charkow and Chile.[1]

var. *melanopus* Al.

Khorásán Class II. Awns black; chaff felted, white with some blackening; grain white, long, thin, translucent, larger than the grain of *Shutur Dandan.*

To this class belongs *Siah Das.* A few similar ears were also found as an impurity in the sample of *Shutur Dandan.*

TRITICUM VULGARE VILL. COMMON WHEATS.

Ears bearded or beardless; outer glumes not keeled to the base; straw hollow; grain neither very long nor very round.

var. *turcicum* Keke.

Khorásán Class III. Ears short, fully bearded; awns red; chaff felted, red; grain white; straw thin.

Only one ear of this wheat was found as an impurity in the *Kar-i-Safid.*

var. *Hostianum* Clem.

Khorásán Class IV. Ears medium to lax, fully bearded; chaff felted, white; grain red, somewhat large, plump.

A very small amount of this wheat was found in the samples of *Kar-i-Safid.* The consistency of the grain was soft.

var. *meridionale* Keke.

Khorásán Class V. Ears somewhat square, medium to lax, fully bearded, awns stiff; chaff felted, white; grain white, somewhat large, plump with a distinct hump; straw fairly stiff.

About one-tenth of the sample *Kar-i-Safid* belongs to this class. The grain had the peculiar dead white colour characteristic of grain in this part of the world and the consistency was medium to hard.

[1] Koernicke, l.c.

var. *ferrugineum* Al.

Khorásán Class VI. Ears long, thin, lax, fully bearded, awns light red; chaff smooth, very light red, shining; grain red.

This variety occurs in very small quantities in *Surkh Das* and in *Kar-i-Safid.*

var. *erythroleucon* Kcke.

Khorásán Class VII. Ears long, thin, lax, fully bearded, awns light red; chaff smooth, very light red, shining; grain large, white.

The wheat *Surkh Das* belongs to this class. This variety also formed about one-tenth of the sample *Kalkori* and occurred as a small impurity in *Kar-i-Safid.*

Khorásán Class VIII. Ears lax, not very long, with short beards along the whole length, awns light red; glumes rounded, smooth, light red with some bloom; grain somewhat large with a distinct hump, white, almost translucent.

The sample *Kalkori* belongs to this class and a similar wheat was also found in small quantity in *Surkh Das.* This wheat resembles in glume-shape and bearding the wheats found on the Simla Hills and while belonging to *T. vulgare* Vill. forms a link between this and *Triticum compactum* Host.

var. *erythrospermum* Kcke

Khorásán Class IX. Ears fairly long, lax, fully bearded, awns white; chaff smooth, shining white; grain light red, fairly large with a distinct hump.

The bulk of the sample *Kar-i-Safid* belongs to this class. This variety also formed about one-tenth of the sample *Safed Khosha.*

var. *graecum* Kcke.

Khorásán Class X. Ears long, thin, lax, fully bearded, awns white; chaff smooth, white; grain somewhat large and white.

To this class belongs the *Safed Khosha* but the sample appears to contain two sub-varieties, one with rounded glumes and plump, soft, white grain and the other with longer, flattened glumes and translucent, t in, amber grain.

About one-eighth of the sample of *Kar-i-Safid* also consisted of a wheat belonging to this class, probably to the sub-variety with plump grain, and a very small quantity was also found in *Shutur Dandan.*

The constitution of the six samples received may therefore be summed up as follows :—

1. *Daima*—Rain-fed wheats.

(*a*) *Kalkori* consists mainly of a wheat with very short awns (var. *erythroleucon* Kcke.) with almost translucent white grain. It is mixed to the extent of about one-twentieth with a wheat belonging to the same variety which is also white-grained but differs from the real *Kalkori* in the amount of bearding and shape of the glumes.

(*c*) *Safed Khosha* consists mainly of wheats belonging to var. *graecum* Kcke. with white grain. It is probable that two sub-varieties, one with plump, soft, white grain and the other with amber, translucent grain occur. There is also admixture to about one-twentieth of var. *erythrospermum* Kcke. with red grain and a very small amount of *Shutur Dandan* wheat.

(*d*) *Surkh Das* consists mainly of var. *erythroleucon* Kcke. with large, soft, white grain. It contained a fair amount of *Kalkori* and a very small amount of two wheats with felted chaff, one with white and one with red grain.

2. *Abi.*—Irrigated wheats.

(*a*) *Kar-i-Safid.* This, according to Major Sykes' report, should be a wheat with a white grain. The sample received under this name consisted, however, in the main (three-quarters of the whole) of a red-grained wheat belonging to var. *erythrospermum* Kcke. A white-grained, smooth-chaffed wheat (var. *graecum* Kcke.) formed about one-eighth and a white-grained, felted wheat (var. *meridionale* Kcke.) about one-tenth of the sample. It also contained small amounts of var. *Hostianum* Clem., var. *erythroleucon* Kcke., var. *ferrugineum* Al. and of var. *turcicum* Kcke. This was the most mixed sample received.

(*b*) *Siah Das* consisted entirely of the macaroni wheat, var. *melanopus* Al. The sample was quite pure and the black colour of the awns well developed, although the grain was slightly shrivelled. This wheat is probably identical with one of the wheats of Baluchistán.

(*d*) *Shutur Dandan.* This is also a macaroni wheat belonging to the variety *Valenciæ* Kcke. This variety occurs nowhere in India but is reported from Valencia in the Russian Province of Charkow and Chile. The sample received was badly matured, having obviously suffered from drought. It contained as impurities very small amounts of *Siah Das* and of a wheat belonging to var. *graecum* Kcke.

The fact that two of the *abi* wheats are macaroni wheats which require a large amount of water explains the statement made by Major Sykes that *abi* seed is never used for *daima* sowings.

The chief characteristics of the Khorásán wheats are the drawn-out appearance of the ears owing to their thinness and laxity, the absence of colour, and the large size of the grain. The long, lax ears with their awns and glumes adpressed to the rachis form a strong contrast to the thicker, squarer ears with bristling awns found in India, although these again appear thin in contrast with European samples. The grain on the whole is large, probably due to the laxity of the ear. The peculiar dead white colour found in Baluchistán is also found here and even when the chaff is red, it is a very pale red. The only strong colour shown was the black of the awns in *Siah das*, which was very well developed. The dryness of the atmosphere was well shown in the clear, shining chaff and straw.

III. THE BARLEYS OF KHORÁSÁN.

Four samples (grain) of barley were also received but no ears.

The following description of the varieties is therefore taken from Major Sykes' report :—

"Barley falls under the following headings :—

1. *Daima*—

   (*a*) *Siah.*
   (*b*) *Kuchani* all called *dopar* or two rows of grain.
   (*c*) *Mushi.*
   (*a*) Ear black ; beard long ; and grain black.
   (*b*) Ear yellow ; beard and grain yellow.
   (*c*) Ear, beard and grain white.

All the above are sown during the month preceding *Nauroz* (21st March).

2. *Abi*—

   (*a*) *Jo shal.*
   (*b*) *Jo zard.*
   (*c*) *Jo siah.*
   (*a*) Ear is white, thin and long ; grain is white and thin with long beard. Four rows of grain.
   (*b*) Full ear, yellow bearded, six rows ; grain is big ; ear, beard and grain yellow.
   (*c*) Ear, beard and grain black, with six rows of grain. The ear is full.

The *Jo kuchani* is considered to be the best."

The following were the samples received :—

Abi.—Jo shal.

Daima.

(*a*) Siah.

(*b*) Kuchani.

(*c*) Mushi.

The sample of *Jo shal* was exceedingly poor and thin and had evidently been grown under very unfavourable conditions. The three *daima* samples were better grown but even they had suffered from want of water, the grains not being properly filled. The fracture of all three was fair, that of *Jo kuchani* being the best, while as regards colour *mushi* was better than *kuchani*. All were mixed with wheat and weed seeds and the sample of *siah* consisted partly of black barley and partly of white. It is possible that with good cultivation both *kuchani* and *mushi* might give fair malting samples.

THE WHEATS OF THE KURRAM VALLEY, NORTH-WEST FRONTIER PROVINCE.

I. INTRODUCTION.

THROUGH the kindness of Mr. S. E. Pears, I.C.S., Political Agent in Kurram, samples of the various kinds of wheat grown in the Kurram Valley were obtained. Seven samples were sent which were all considered to be distinct varieties by the local farmers.

The following samples were received :—

No.	TRACT	VILLAGE	VARIETY
1.	Rodghara	Shakh	Red
2.	Rodghara	Shakh	White
3.	Daman	Shiblan	Red
4.	Daman	Shalozan	Red
5.	Daman	Zeran	White
6.	Daman	Zeran	Red
7.	Sahra	Párachinár	White

The Kurram Agency forms part of the North-West Frontier Province and consists of a long, narrow valley (length 72 miles, breadth 12 to 24 miles). It is bounded on the north-east by the Safed Koh Range of the Himalayas whose highest peak Sikharám, 15,620 ft., is at the extreme north-west corner of the Agency. Other lower ranges form the boundary on the west and on the south and from the southern range runs a spur which divides the valley into two parts, Upper and Lower Kurram. Thus Upper Kurram is almost surrounded by mountains. The Kurram River, a tributary of the Indus is the only river in the Valley. Párachinár (the head-quarters) and most of the villages are situated on the wide open plain of Upper Kurram whereas only narrow strips of cultivation along the river banks are found in Lower Kurram. In Lower Kurram the summer is hot and dry and the winter cold with a bitter wind, while in Upper Kurram the summer is never very hot but snow lies on the ground for weeks in winter. The highest temperature at Párachinár was 97°—100° and the minimum 11°·8 in 1900.

Generally speaking, the North-West Frontier Province has two wet seasons, one due to the monsoon and one to winter storms from Mesopotamia

and Persia bringing rain and snow. Both are precarious and may fail entirely.

The soil of the Kurram Valley is very fertile wherever irrigation is obtainable. Owing to the unsettled nature of the country in the past, however, no permanent system of irrigation has been made and irrigation is only carried on by small channels made and owned by a hamlet or a family. There are two harvests, the autumn harvest of rice, maize and oilseeds and the spring harvest of wheat, barley and clover, of which the former is the more valuable although the spring harvest is now increasing in importance.

II. CLASSIFICATION AND DESCRIPTION OF THE WHEATS.

A. CLASSIFICATION OF THE WHEATS OF THE KURRAM VALLEY.

TRITICUM VULGARE VILL. COMMON WHEATS.

I. Ears bearded.

1. Glumes smooth.

A. Glumes red.

(a) Grain red.

var. *ferrugineum* Al.

Kurram Valley Class I.

(b) Grain white.

var. *erythroleucon* Kcke.

Kurram Valley Class II. Ears long; grain long, somewhat grey in tone; straw stout.

Kurram Valley Class III. Ears short; glumes short and rounded; grain short with a distinct hump, yellow in tone; straw weak.

B. Glumes white.

(a) Grain red.

var. *erythrospermum* Kcke.

Kurram Valley Class IV. Ears long; glumes long; grain long, very pale yellowish red.

Kurram Valley Class V. Ears short; glumes short and rounded; grain short with a distinct hump, bright red in colour.

(*b*) Grain white.

var. *graecum* Kcke.

Kurram Valley Class VI.

B. DESCRIPTION OF THE WHEATS OF THE KURRAM VALLEY.

Triticum Vulgare Vill. Common wheats.

Ears bearded or beardless; outer glumes not keeled to the base; straw hollow; grain neither long nor round.

var. *ferrugineum* Al.

Kurram Valley Class I. Ears medium, fully bearded; chaff smooth, brownish red; grain pale red; straw pink, turning grey on ripening.

It is possible that the wheats belonging to this class could be divided into two sub-classes with grain of different tones of red but the specimens are not well enough grown to state this with certainty.

Wheat belonging to this class occurred in all the samples as an impurity; in fair quantity in sample 6 from Zeran, Daman and in sample 1 from Shakh, Rodghara; in small quantity in sample 3 from Shiblan, Daman, sample 5 from Zeran, Daman, sample 4 from Shalozan, Daman, sample 2 from Shakh, Rodghara, and sample 7 from Párachinár, Sahra.

var. *erythroleucon* Al.

There appear to be two classes within this botanical variety, differing in the shape of the glume and of the grain.

Kurram Valley Class II. Ears long, medium, square, fully bearded, awns red; glume-shape normal; chaff smooth, brownish red with a bluish bloom; grain long, white, somewhat grey in tone; straw strong, almost solid, pink turning black on ripening.

To this class belong sample 3 from Shiblan, Daman, sample 5 from Zeran, Daman, and sample 1 from Shakh, Rodghara.

Kurram Valley Class III. Ears short, medium, square, fully bearded, awns red; glumes somewhat rounded, smooth, brownish red with a bluish bloom; grain short with a distinct hump, yellow in tone; straw thin, pink, turning grey on ripening.

To this class belongs sample 4 from Shalozan, Daman, and a small part (about one-third) of sample 7 from Párachinár, Sahra.

Single ears belonging to these classes are difficult to distinguish from one another but in the mass the wheats present a very different appearance. The wheats belonging to Class II are strong and vigorous with a large beard and stout straw, while those in Class III are much smaller and weaker.

var. *erythrospermum* Kcke.

There are again two classes belonging to this botanical variety differing in the shape of the glume and the shape of the grain.

Kurram Valley Class IV. Ears long, medium to lax, fully bearded, awns white ; glumes long, smooth, yellowish white with a reddish tinge ; grain long, thin, very pale red, yellow in tone.

To this class belongs sample 2 from Shakh, Rodghara.

Kurram Valley Class V. Ears medium in length, medium to lax, fully bearded, awns white ; glumes short and rounded, smooth, white with a reddish tone ; grain short, with a distinct hump, red, a deeper red than in Class IV and without the yellow tint of the latter.

Wheats belonging to this class were only found as admixtures : in fair quantity in sample 7 from Párachinár, Sahra, and in small quantity in sample 3 from Shiblan, Daman, sample 4 from Shalozan, Daman, and sample 5 from Zeran, Daman.

The difference in the shape and grain colour between these two classes is very great.

var. *graecum* Kcke.

Kurram Valley Class VI. Ears long, medium, fully bearded ; awns white ; chaff smooth, white with a reddish tone ; grain long, white ; straw fairly strong, pink, turning grey on ripening.

Wheats belonging to this class were only found as an impurity in some of the samples. They were found in fair quantity in sample 3 from Shiblan, Daman, and in sample 2 from Shakh, Rodghara ; in very small quantity in sample 4 from Shalozan, Daman, and sample 7 from Párachinár, Sahra.

var. *turcicum* Kcke.

Ears fully bearded, awns red ; chaff felted, red ; grain white.

Only one ear belonging to this variety was found in sample 4 from Shalozan, Daman.

The constitution of the seven samples of wheat received may be summed up as follows :—

SAMPLE 1.—WHITE WHEAT FROM SHAKH, RODGHARA.

The bulk of this sample consisted of the strong, vigorous, red-chaffed white-grained wheat, Kurram Valley Class II (var. *erythroleucon* Al.). About one-eighth of the sample however belonged to Kurram Valley Class I (var. *ferrugineum* Al.) which is similar in outward appearance but in which the grain is pale red.

SAMPLE 2.—RED WHEAT FROM SHAKH, RODGHARA.

Seven-eighths of this sample consisted of a fully bearded, white-chaffed, very pale red-grained wheat Kurram Valley Class IV (var. *erythrospermum* Kcke.)

It also contained a similar wheat with white grain, Kurram Valley Class VI (var. *graecum* Kcke.) and a small quantity of a wheat belonging to var. *ferrugineum* Al., Kurram Valley Class I.

SAMPLE 3.—RED WHEAT FROM SHIBLAN, DAMAN.

About three-quarters of this sample consisted of the red-chaffed, white-grained wheat belonging to Kurram Valley Class II (var. *erythroleucon* Al.). The rest of the sample consisted of a white-chaffed, white-grained wheat, Kurram Valley Class VI (var. *graecum*, Kcke.), with small quantities of two red-grained wheats, one red-chaffed, Kurram Valley Class I (var. *ferrugineum* Al.) and the other white-chaffed, Kurram Valley Class V (var. *erythrospermum* Kcke.).

SAMPLE 4.—RED WHEAT FROM SHALOZAN, DAMAN.

This sample consisted almost entirely of a wheat belonging to Kurram Valley Class III (var. *erythroleucon* Kcke.). Small quantities of wheats belonging to Kurram Valley Class I (var. *ferrugineum* Al.), Kurram Valley Class V (var. *erythrospermum* Kcke.) and Kurram Valley Class VI (var. *graecum* Kcke.) also occurred.

SAMPLE 5.—WHITE WHEAT FROM ZERAN, DAMAN.

This sample was somewhat immature. The bulk (nine-tenths) consisted of the red-chaffed, white-grained wheat, Kurram Valley Class II (var. *erythroleucon* Kcke.) with small quantities of two red-grained wheats, one red-chaffed (var. *ferrugineum* Al.), Kurram Valley Class I, and the other white-chaffed (var. *erythrospermum* Kcke.), Kurram Valley Class V.

SAMPLE 6.—RED WHEAT FROM ZERAN, DAMAN.

This sample was rather poor and not so well-grown as the others. It consisted of two wheats only. Two-thirds of the sample was composed of the red-chaffed, white-grained wheat, Kurram Valley Class II (var. *erythroleucon* Al.) and the rest to Kurram Valley Class I (var. *ferrugineum* Al.) which is similar in appearance but has red grain.

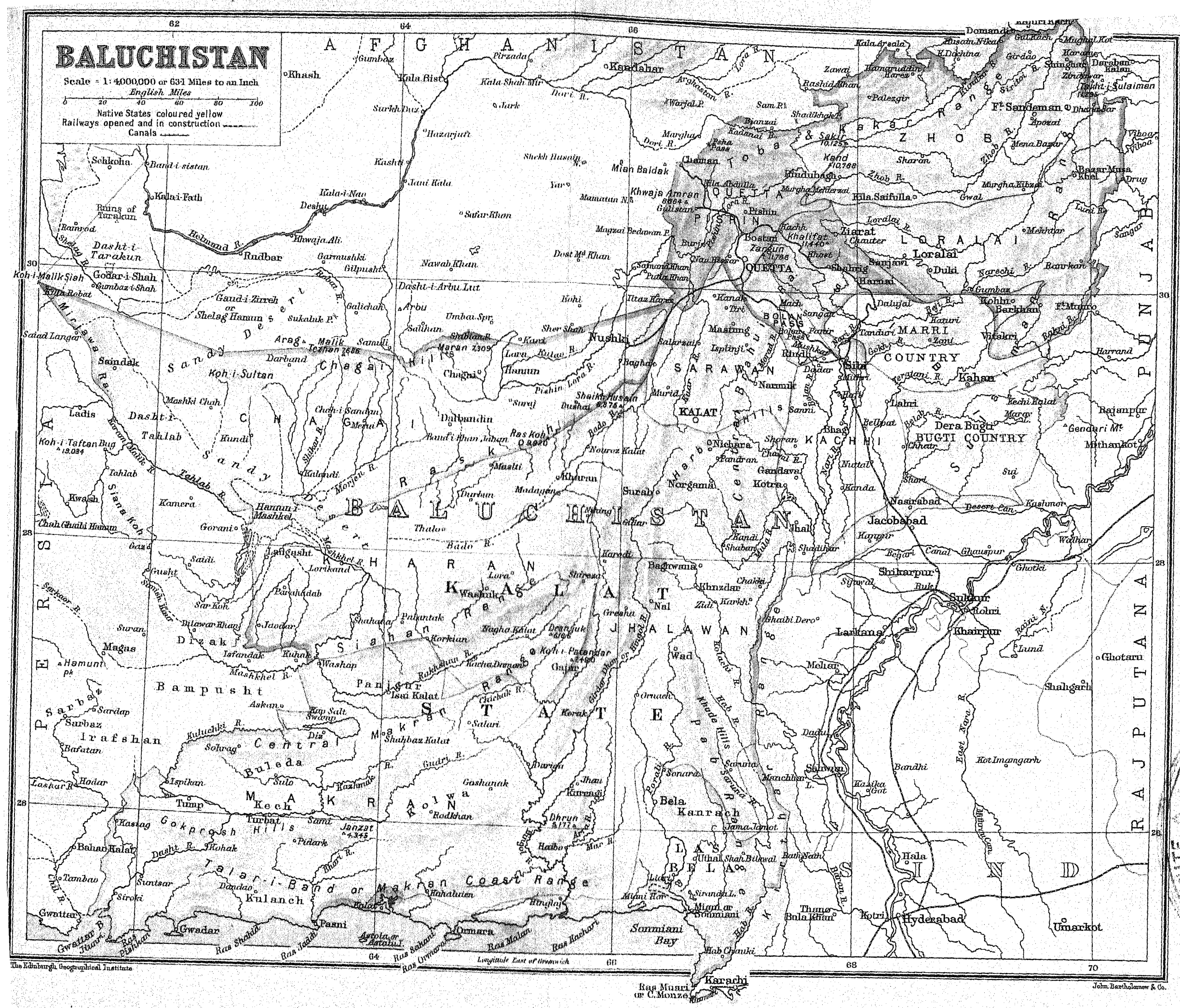
SAMPLE 7.—WHITE WHEAT FROM PARACHINAR, SAHRA.

This sample was the most mixed of all. It was impossible to make out which was the main constituent. About one-third of the sample consisted of the red-chaffed, white-grained wheat, Kurram Valley Class II (var. *erythroleucon* Kcke.), about one-third belonged to the white-chaffed, red-grained wheat, Kurram Valley Class V (var. *erythrospermum* Kcke.) and the rest consisted of small quantities of the wheats, Kurram Valley Classes III and VI.

The most striking point about the Kurram Valley wheats is the paucity of varieties. There are only four varieties and six classes. Only common wheats occur, the black-awned macaroni wheat so common in the North, *i.e.*, in the Punjab, Baluchistán and Khorásán, is absent. The wheats are very similar in appearance. They are all fully bearded with smooth chaff. Only one tone of red is present in the chaff colour, a brownish red with a kind of bluish bloom overlying it, somewhat similar to the chaff of Punjab Type 12 but without the blackening of the awns found in this type. The straw in many of these wheats shows the peculiarity observed in several of the Punjab wheats, viz., a pink colour before maturity which turns grey or black on ripening. One interesting point is the occurrence in two cases, Classes II and III and Classes IV and V, of two wheats morphologically identical except as regards glume-shape, grain-shape (which is of course correlated with the shape of the glume) and tone of colour of the grain.

The consistency of the grain of all the kinds was soft and no indication of quality could be observed. They appear all to be essentially weak wheats of poor quality. The grains were not well-filled. It is probable that, as everywhere on the Frontier, wheats with a somewhat shorter growing period would give a better sample of grain and would grow more profitably. Both earcockle and bunt were found in the samples.

PUSA:
October 28, 1915.



BALUCHISTAN
Scale = 1:4,000,000 or 63.1 Miles to an Inch
English Miles
0 20 40 60 80 100
Native States coloured yellow
Railways opened and in construction
Canals
AFGHANISTAN
PERSIA
PUNJAB
RAJPUTANA
SIND
BALUCHISTAN
KALAT STATE
KHARAN
JHALAWAN
SARAWAN
KACHHI
MAKRAN
ZHOB
LORALAI
QUETTA
PISHIN
MARRI COUNTRY
BUGTI COUNTRY
LAS BELA
Kandahar
Quetta
Kalat
Nushki
Jacobabad
Shikarpur
Sukkur
Hyderabad
Karachi
Gwadar
Pasni
Ormara
Sonmiani Bay
Ras Muari or C. Monze
Longitude East of Greenwich
62
64
66
68
70
30
28
26
The Edinburgh Geographical Institute
John Bartholomew & Co.

OBSERVATIONS ON THE INHERITANCE OF ANTHOCYAN PIGMENT IN PADDY VARIETIES.

BY

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A considerable proportion of paddy varieties are characterized by the presence of reddish and purplish anthocyan pigment distributed throughout various parts of the plant. The varieties so far studied at Dacca may, with reference to the distribution of the pigment, be broadly classified as follows :—

(1) Leaf-sheaths, apiculus of the glumes, and stigma coloured.

(2) Leaf-sheath and apiculus of glumes coloured, but stigma colourless (white).

(3) Apiculus of glumes and stigma coloured, but leaf-sheaths colourless.

(4) Apiculus of glumes only coloured.

Class 1 is the commonest group—2, 3 and 4 containing comparatively few members.

The colours concerned range from red through purples to almost black, and it is noteworthy that in some of these coloured types the colour in the stigma is a darker shade than the colour in the leaf-sheath and apiculus, and, as will be shown below, appears to contain in such cases additional colour factors not present in the leaf-sheath and apiculus.

It is somewhat doubtful if classes 3 and 4 really exist. The apparent absence of colour in the leaf-sheath in these cases may, as is suggested by

Graham[1] with reference to the Central Provinces' varieties, perhaps be due to the fact that the colour is of so faint and fleeting a nature as to escape detection, more especially so as the intensity of the colour appears to be considerably affected by environmental conditions. Moreover, all paddies so far examined which have a coloured leaf-sheath seem also to have a coloured apiculus, and as Graham[1] states, the converse may also be true, as the colour in the leaf-sheath and apiculus seems to be the same and behaves in inheritance as if due to the same factors.

The colour in the stigma, on the other hand, does not always correspond with the leaf-sheath and apiculus colour. It may be colourless, though colour is present in the leaf-sheath and apiculus, or it may be of the same colour as the leaf-sheath and apiculus, or it may be of a darker shade. The colour in the leaf-sheath can generally be detected in the cotyledonary leaf of the young seedling, if fully exposed to sunlight (*cf.* Plate I, fig. 1), and counts of this character can be made in seedlings of a few days old.

The following observations on the inheritance of these colours have been made incidental to work of a more practical nature. Their complete elucidation will involve a long series of analyses extending over some length of time, but the results so far obtained show that their inheritance is on the same lines as have been proved to hold in the case of *Lathyrus*, *Matthiola*, *Antirrhinum* and *Primula* investigated by Bateson, Punnett, Saunders,[2] Wheldale,[3] Gregory[4] and others. The results quoted have mostly been obtained from the analysis of the offspring of natural crosses, but some results from artificial crosses, so far as available up to date, are also included.

(1) *The 9 : 7 ratio in the leaf-sheath.*

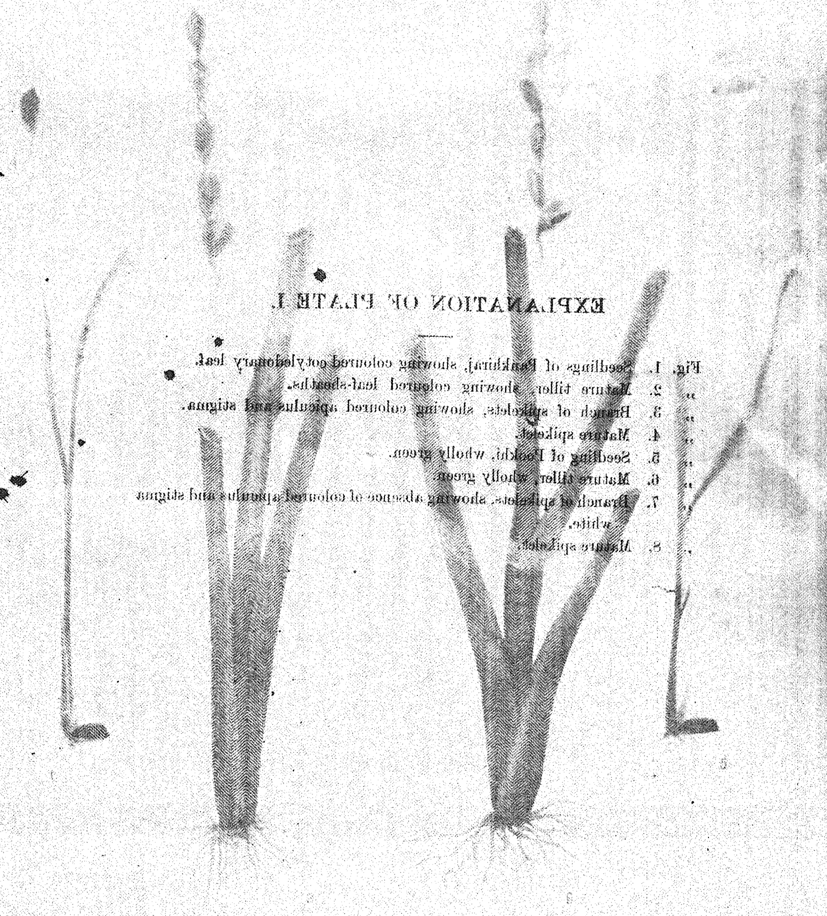
In the season of 1912, forty-eight natural crosses characterized by the presence of red pigment in the leaf-sheaths were found in our pure line plots, and in 1913 these all split in the seed-beds into various coloured reds and green, the total number of the reds to the green being 12,122 to 9,007, a close approximation to the now well-authenticated Mendelian ratio 9 : 7, the expectation

[1] Graham, R. J. D. Preliminary Note on the Classification of Rice in the Central Provinces. *Memoirs, Department of Agriculture, India, Botanical Series*, vol. VI, no. 7, 1913.

[2] Bateson, W., Saunders, E. R., and Punnett, R. C. *Reports to Evolution Com. Roy. Soc.*, III, 1906, page 31.

[3] Wheldale, M. Inheritance of Flower Colour in *Antirrhinum majus*, *Proc. Roy. Soc.*, 79 B., 1907, page 288, etc.

[4] Gregory, R. P. Experiments with *Primula sinensis*, *Journal of Genetics*, I, no. 2, March 1911, pages 94—124.

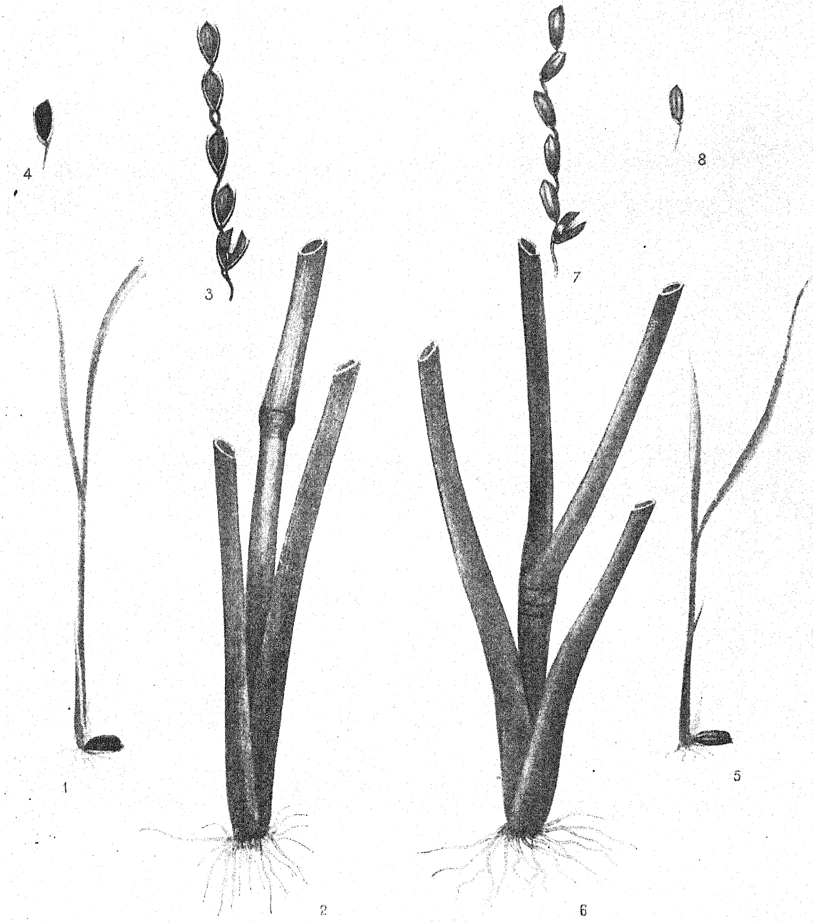


Figs. 1-4. VAR. PANKHIRAJ.

Figs. 5-8. VAR. POOKHI.

EXPLANATION OF PLATE I.

Fig. 1. Seedlings of Pankhiraj, showing coloured cotyledonary leaf.
,, 2. Mature tiller, showing coloured leaf-sheaths.
,, 3. Branch of spikelets, showing coloured apiculus and stigma.
,, 4. Mature spikelet.
,, 5. Seedling of Pookhi, wholly green.
,, 6. Mature tiller, wholly green.
,, 7. Branch of spikelets, showing absence of coloured apiculus and stigma white.
,, 8. Mature spikelet.



Figs. 1-4. VAR. PANKHIRAJ.

Figs. 5-8. VAR. POOKHI.

on this basis being 11,885·1 to 9,243·9. Two to three hundred seedlings from each of forty-five of these seed-beds were transplanted at random in the field and in the same year subsequent counts of the mature plants gave 6,265 reds : 4,846 green, the expectation being 6,249·94 : 4,861·06, a still closer approximation to the 9 : 7 ratio.

In the years 1913 and 1914 detailed counts were also made in the field of 10 plots raised from similarly coloured natural crosses selected for their colour characters in 1912 and 1913, and the results are tabulated below :—

TABLE I.

Serial No.	Leaf-sheath red, Apiculus red	Leaf-sheath green, Apiculus green	Expectation
No. 20, 1913	106	76	102·4 : 79·6
,, 22, 1914	63	49	63·0 : 49·0
,, 23, ,,	58	60	66·4 : 51·6
,, 24, ,,	58	49	60·2 : 46·8
,, 25, ,,	57	56	63·6 : 49·4
,, 29, ,,	80	34	64·2 : 49·8
,, 39, ,,	70	43	63·6 : 49·4
,, 57, ,,	81	13	52·9 : 41·1
,, 30, ,,	75	39	64·2 : 49·8
,, 64, ,,	23	12	19·7 : 15·3
Total	671	431	719·9 : 482·1

Adopting the notation employed by Bateson, Saunders and others, if R be considered the factor which in presence of a chromogen base C produces the red colour, then the simplest explanation of these cases is to suppose that the coloured parent was of the constitution CR and the green (colourless) cr. The F_1 hybrid will then have the constitution RrCc, and on selfing will give rise to plants of the following constitutions :—

9RC—red,
3Rc—green,
3Cr—green.
1cr—green,
i.e. 9 red : 7 green.

On this hypothesis, it is seen there will be four kinds of reds, *viz.* : RRCC RrCc, RrCC, RRCc. No attempt has so far been made to sort out the different shades of red, but it is undoubted that various shades of red do occur in the F_2.

In reality, however, as will be seen from further examples discussed below, the constitution of the parents may have been much more complicated.

(2) *Examples of* 3 : 1 *ratios.*

In a few cases the simple 3 : 1 ratio has been obtained. An example of this was afforded by the heterozygous type Ba 1, noted in a former paper,[1] picked from a variety named Gobrabali in 1911. The parent had a red apiculus to the glumes, red awns and a coloured stigma, and in 1912 split into

1. Red awns, glumes with red apiculus, coloured stigma, 73,
2. White awns, glumes with green apiculus, white stigma, 23,

giving a ratio 3·17 coloured : 1 colourless. Here the colour in apiculus, awns and stigma behaves as a single unit and may perhaps be due to the same simple factor or to the same interacting factors. If the latter, the simplest explanation would be to suppose the parent heterozygous for one of the factors, *i.e.*, of the constitution RrC or RCc.

Five of these coloured plants selected in 1912 again split in 1913 in the proportions shown below :—

TABLE II.

1913 Plot No.	Coloured awns, apiculus and stigma	White awns, green apiculus, white stigma	Ratio
77	91	23	3·9 : 1
78	155	56	2·7 : 1
79	129	43	3·0 : 1
80	188	72	2·6 : 1
81	126	45	2·8 : 1
82	122	40	3·05 : 1
83	108	45	2·4 : 1
84	126	47	2·6 : 1
85	85	26	3·2 : 1
Total	1,130	397	2·8 : 1

[1] Hector, G. P. Notes on Pollination and Cross-fertilization in the Common Rice Plant, *Oryza sativa*, Linn. *Memoirs, Dept. of Agri., India, Bot. Series*, vol. VI, no. 1, 1913.

Another case of red colour giving the 3 : 1 ratio affected the apiculus of the glumes only. A hybrid parent with red apiculus to the glumes but no apparent colour elsewhere selected in 1912, gave in 1913, 75 plants with red apiculus : 25 with no apiculus.

The above cases are all from natural crosses. In 1913 several artificial crosses were made between a wholly green variety (Pookhi, Plate I, figs. 5–8) and a variety with marked reddish colour in the leaf-sheath and glume-apex, and a purple colour in the stigma (Pankhiraj, Plate I, figs. 1–4). The F_1 plants (1914) showed the colour characters almost wholly dominant.

In 1915 the following results were obtained with reference to colour characters :—

	Coloured eaf-sheath, apiculus and stigma	Colourless	Ratio
No. 1 Pookhi ♀ × Pankhiraj ♀	67	30	2·2 : 1
„ 2 „ „	200	67	2·9 : 1
„ 3 „ „	267	69	3·8 : 1
„ 4 „ „	116	30	3·8
„ 5 Pankhiraj ♀ × Pookhi ♀	365	121	3·01 : 1
Total	1,015	317	3·2 : 1

Here, again, the colour in the leaf-sheath, apiculus and stigma behaves as a single unit and may be due to one simple factor ; or it is necessary to suppose that the green parent possessed one of the factors necessary for the production of colour, but was lacking in the other, *i.e.*, that the cross is of the nature RC × rC or Rc.

(3) *Purple colour in the stigma due to three interacting factors.*

It has been noted above that in some of our types with colour in the leaf-sheath, apiculus and stigma, the colour in the leaf-sheath and apiculus is some shade of red, while that in the stigma is a deeper purple. Graham[1] states with reference to the coloured varieties in the Central Provinces that where the stigma is coloured, the colour of the stigma corresponds with the colour in the leaf-sheaths; th se with red leaf-sheath having a red stigma, those with bluish or purplish leaf-sheath having a blue or purple stigma.

[1] Graham, *loc. cit.*

We have not found this to be the case in all our types, many having some shade of red in the leaf-sheath, but a blue-black colour in the stigma, and the evidence quoted below proves that in some of these cases this purple stigma colour appears to be due to the interaction of three factors, and furthermore that the simultaneous presence of all three appears necessary for the production of colour at all.

The cases discussed here with reference to the stigma colour are the same as those quoted above (Table I) in which the leaf-sheaths gave the 9 : 7 ratio. The parents, selected in 1912 and 1913, had reddish coloured leaf-sheaths, red apiculus and blue-black stigmas, and in 1913 and 1914 gave the results below :—

TABLE III.

Serial No.	Leaf-sheath red, apiculus red, stigma coloured of various shades	Leaf-sheath red, apiculus red, stigma white	Leaf-sheath green, apiculus green, stigma white	Coloured stigma : White stigma	Expectation
22, 1914	44	19	49	44 : 68	47·2 : 64·8
23, ,,	42	16	60	42 : 76	49·7 : 68·3
24, ,,	40	18	49	40 : 67	45·1 : 61·9
25, ,,	46	11	56	46 : 67	47·6 : 65·4
29, ,,	47	33	34	47 : 67	48·09 : 65·91
39, ,,	42	28	43	42 : 71	47·5 : 65·4
57, ,,	14	67	13	14 : 80	39·6 : 54·4
20, 1913	78	28	76	78 : 104	76·7 : 105·3
30, 1914	62	13	39	62 : 52	48·09 : 65·91
64, ,,	22	1	12	22 : 13	14·7 : 20·3
Total	437	234	431	437 : 665	465·7 : 638·3

If we again adopt the usual notation for such cases, the above results could be produced by supposing that (1) the colour in the leaf-sheath and apiculus is due to a colour factor R acting on a Chromogen base C, (2) that the purple colour of the stigma is due to a further factor P not present in the leaf-sheath and apiculus, and (3) that the simultaneous presence of all three factors RCP is necessary for the production of colour of any sort in the stigma.

If this explanation is correct, then the constitution of the F_1 plants with reference to the stigma must be Cc Rr Pp and these on selfing will give rise to :—

(1)	27	plants of constitution	CRP—	coloured stigma,	red leaf-sheath,	red apiculus.
(2)	9	,, ,,	CR—	white ,,	,,	,,
(3)	9	,, ,,	PR—	,, ,,	green leaf-sheath and	apiculus.
(4)	9	,, ,,	CP—	,, ,,	,,	,,
(5)	3	,, ,,	R—	,, ,,	,,	,,
(6)	3	,, ,,	C—	,, ,,	,,	,,
(7)	3	,, ,,	P—	,, ,,	,,	,,
(8)	1	,, ,,	crp—	,, ,,	,,	,,

i.e., 27 coloured : 37 white stigmas or 1 : 1·3.

The interesting point in these cases lies in the fact that the 9 plants of constitution CR would normally be expected to have stigmas of a reddish colour like the leaf-sheaths, as both the factors necessary for the production of red colour in the leaf-sheath and apiculus are present here in the stigma, the purple factor P only being absent, but in not a single case could a trace of colour be found in these. What the explanation of this is has not yet been determined. A possible explanation is that there is here some factor in the stigma which inhibits the production of the colour, except when the additional factor P is present. If so, then these white stigmas of the constitution CR should prove dominant over similarly constituted red stigmas amongst coloured types. Amongst the coloured stigmas, it was possible to detect various shades, some apparently red, but no attempt has yet been made to separate these. This also would explain the occasional occurrence of pure-breeding types with coloured leaf-sheaths, apiculus and white stigma, the second class referred to in the beginning. Such types may have been produced through the agency of natural crossing and some may prove to be dominant whites. If so, then these cases would seem to be comparable to the red-stemmed, dominant white flowers described by Gregory[1] in the case of Primulas.

Assuming this explanation, in the F_3 generation out of every 27 coloured stigmas,

1	should produce	coloured only.
6	,, ,,	3 coloured : 1 white.
12	,, ,,	9 coloured : 7 white.
8	,, ,,	27 coloured : 37 white.

and it should also be possible to produce the colour by inter-crossing many of the whites.

[1] Gregory, *loc. cit.*, p. 115.

(4) *Colour due to three and four interacting factors.*

The cross discussed below was made in the season 1912 between a wholly green, awnless variety with white stigma, Chittagong No. 25 (Plate II, figs. 5–8), and a variety with reddish purple leaf-sheaths, apiculus and awns, and a deep blue-black stigma, Chittagong No. 9 (Plate II, figs. 1-4). Four successful crosses were obtained, but unfortunately during the absence of the writer on tour, three of the F_1 plants were eaten by insects and the result of only one, C25 ♀ × C9 ♀ are so far available. The cross has since been repeated, but the results will not be forthcoming for another year.

In the F_1 the colour characters appeared to be almost wholly dominant, though the colours were not quite so pronounced as in the coloured parent. Five hundred and twenty-nine plants were bred to the F_2 generation during the season 1914 and gave the following figures with reference to colour characters :—

(1) Red leaf-sheaths ; red apiculus ; coloured stigma		.. 180	} 250
(2) ,, ,, white stigma		.. 70	} 250 / } 349
(3) Green leaf-sheaths ; green apiculus ; ,,		.. 279	} 349
i.e., coloured leaf-sheath and apiculus	250 : green	.. 279	
Expectation	223·1 :	.. 305·9	
Coloured stigma	180 : white	.. 349	
Expectation	167·3 :	.. 361·7	

Confirmation of the above figures has also been obtained from the analysis of the offspring of a natural hybrid selected from the pure line plot of Chittagong No. 9 in 1914, only in this example the male parent is unknown. In the present season 1915 the following figures were obtained :—

(1) Red leaf-sheath ; red apiculus ; coloured stigma		.. 28	} 47
(2) ,, ,, white stigma		.. 19	} 47 / } 71
(3) Green leaf-sheath ; green apiculus ; white stigma		.. 52	} 71
i.e., coloured leaf-sheath and apiculus	47 : green	.. 52	
Expectation	41·7 :	.. 57·3	
Coloured stigma	28 : white	.. 71	
Expectation	31·3 :	.. 67·7	

Here the figures closely approximate to the expectation on a basis of three interacting factors for the leaf-sheath and apiculus colour, and four for the stigma, otherwise this case is exactly comparable to those in Table III, and the constitution of the F_2 types will be as under, using B for the extra colour factor in the stigma :—

81—CRPB—Coloured leaf-sheath, apiculus and stigma.

27—CRPb— ,, ,, , stigma white.

EXPLANATION OF PLATE II.

Fig. 1. Seedling of Chittagong 9, showing coloured cotyledonary leaf.
" 2. Mature tiller, showing coloured leaf-sheaths.
" 3. Branch of spikelets, showing coloured apiculus and stigma.
" 4. Mature spikelet.
" 5. Seedling of Chittagong 25, wholly green.
" 6. Mature tiller, wholly green.
" 7. Branch of spikelets, showing no coloured apiculus and stigma white.
" 8. Mature spikelet.

Figs. 1-4. CHITTAGONG No. 9.

Figs. 5-8. CHITTAGONG No. 25.

27—CRBp—	Green leaf-sheath,	apiculus,	stigma white.
27—cRPB—	,,	,,	,,
27—rCPB—	,,	,,	,,
9—pbCR—	,,	,,	,,
9—rbPC—	,,	,,	,,
9—rpBC—	,,	,,	,,
9—cbRP—	,,	,,	,,
9—crPB—	,,	,,	,,
9—pcBR—	,,	,,	,,
3—rpbC—	,,	,,	,,
3—cpbR—	,,	,,	,,
3—rcbP—	,,	,,	,,
3—crpB—	,,	,,	,,
1—rcpb—	,,	,,	,,

Assuming the previous explanation, in this case, as well as dominant white stigmas, there should also be found greens amongst the types with green leaf-sheath and apiculus dominant over red coloured leaf-sheaths among coloured types, and it should be possible to produce colour in the leaf-sheath by inter-crossing many of the greens. Such green types are really coloured but by virtue of their containing some inhibiting factor or factors which prevent the appearance of the colour except when all the colour factors are present, the colour is not produced, and the result is a plant with a green leaf-sheath.

Amongst the 81 plants with coloured stigmas there will be stigmas of 16 different constitutions, which should in the F_3 produce coloured : colourless in the proportions below, *viz.*,

1	should produce all	coloured.		
8	,,	3 coloured	: 1	white.
24	,,	9 ,,	: 7	,,
32	,,	27 ,,	: 37	,,
16	,,	81 ,,	: 175	,,

Amongst the 16 differently constituted stigmas, there should be also a considerable range of colour and it was possible without much difficulty to make out 4 main classes, *viz.*, blue-black, blue, reddish brown, and red.

The leaf-sheath colour, on the other hand, should behave in the F_3 in the same way as has already been pointed out above in the case of the stigma with three factors. All the coloured F_2 plants from the cross C 25 ♀ × C9 ♀ have been sown in the present season 1915, and the following table gives the

result for leaf-sheath colour in 107 F_3 plots picked at random from these. The figures again show a close approximation to the expectation on a basis of three interacting factors.

R : G 27 : 37. No. expected 32		R : G 9 : 7. No. expected 48		R : G 3 : 1 No. expected 24		Pure Red No. expected 4	
Plant No. 1914	1915	Plant No. 1914	1915	Plant No. 1914	1915	Plant No. 1914	1915
2	92 : 103	3	38 : 26	12	173 : 54	27	Pure Red.
7	74 : 111	4	99 : 51	18	138 : 37	33	"
10	74 : 100	5	102 : 78	21	153 : 32	39	"
11	88 : 95	6	90 : 90	25	117 : 54	44	"
15	74 : 80	8	95 : 91	28	148 : 47	46	"
30	90 : 103	9	92 : 48	31	127 : 58	58	"
37	28 : 77	13	62 : 61	38	112 : 48	91	"
43	95 : 96	14	97 : 62	40	156 : 73	92	"
57	78 : 100	16	163 : 144	41	112 : 32	106	"
73	33 : 152	17	112 : 74	56	123 : 49	123	"
76	87 : 101	19	91 : 68	59	134 : 34	125	"
77	54 : 137	22	124 : 71	61	130 : 58		
79	75 : 116	23	102 : 95	62	105 : 48		
80	33 : 141	29	41 : 35	65	121 : 40		
81	66 : 86	35	109 : 67	78	129 : 60		
84	100 : 198	36	104 : 73	82	106 : 28		
88	67 : 133	42	103 : 76	83	135 : 55		
89	89 : 109	45	89 : 76	85	151 : 31		
94	84 : 86	47	98 : 80	93	139 : 60		
100	37 : 149	50	119 : 61	95	160 : 38		
103	85 : 91	52	101 : 89	96	140 : 31		
104	65 : 89	53	96 : 79	97	158 : 34		
105	99 : 100	57	77 : 76	99	152 : 63		
108	83 : 93	60	73 : 69	110	113 : 41		
112	85 : 91	63	98 : 87	111	60 : 24		
119	60 : 71	64	99 : 89	114	100 : 39		
		66	106 : 83	131	160 : 30		
		68	118 : 65	143	160 : 40		
		70	59 : 41				
		71	103 : 75				
		72	140 : 67				
		74	89 : 84				
		75	102 : 86				
		86	100 : 89				
		87	100 : 97				
		101	110 : 85				
		102	127 : 67				
		107	101 : 88				
		109	126 : 77				
		113	101 : 98				
		121	100 : 96				
		122	100 : 77				
Total 26 ...	1895 : 2808	42	4156 : 3191	28	3712 : 1238	11	
Expected 32	1984·07:2718·9	48	4132·7:3214·3	24	3712·5:1237·5	4	

As regards stigma colour, the numbers could be counted in only a few plots, owing to the short period of time in which it is possible to determine stigma colour accurately. Hence it has not been possible to verify the relative proportions in which the different types of splitting occur, but apparent examples of all the different ratios of coloured : white expected, *viz.*, 3 : 1, 9 : 7, 27 : 37, and 81 : 175 have been found, as shown below :—

1. Leaf-sheath pure red, stigma ratio 3 : 1.

Plant No. 27.

Leaf-sheaths and glume apex coloured, stigma coloured ..	129	
" " " " white ..	49	
Expectation	133·5	
	44·5	

2. Leaf-sheath ratio 3 : 1, stigma 9 : 7.

Plant No. 31.

Leaf-sheath and glume apex coloured, stigma coloured ..	98	127
" " " " white ..	29	
" " green, " white ..	58	87
Expectation	104·06	138·8
	34·74	
	46·2	80·9

Plant No. 110.

Leaf-sheath and glume apex coloured, stigma coloured ..	85	113
" " " " white ..	28	
" " green, " " ..	41	69
Expectation	86·6	115·5
	28·9	
	38·5	67·4

Plant No. 12.

Leaf-sheath and glume apex coloured, stigma coloured ..	134	173
" " " " white ..	39	
" " green, " " ..	54	93
Expectation	127·6	170·3
	42·7	
	56·7	99·4

Plant No. 83.

Leaf-sheath and glume apex coloured, stigma coloured ..	99	135
" " " " white ..	36	
" " green, " " ..	55	91
Expectation	106·8	142·5
	35·7	
	47·5	83·2

Plant No. 85.

Leaf-sheath and glume apex coloured, stigma coloured ..	124	151
" " " " white ..	27	
" " green, " " ..	31	58
Expectation	102·3	136·5
	34·2	
	45·5	79·7

Plant No. 40.

Leaf-sheath and glume apex coloured, stigma coloured ..	100	156
,, ,, ,, ,, white ..	56	
,, ,, green, ,, ,, ..	73	129
Expectation	128·8	171·8
	43·0	
	57·2	100·2

3. Leaf-sheath ratio 9 : 7, stigma 27 : 37.

Plant No. 16.

Leaf-sheath and glume apex coloured, stigma coloured ..	107	163
,, ,, ,, ,, white ..	56	
,, green, ,, ,, ..	144	200
Expectation	129·5	172·7
	43·2	
	134·3	177·5

Plant No. 64.

Leaf-sheath and glume apex coloured, stigma coloured ..	75	99
,, ,, ,, ,, white ..	24	
,, ,, green, ,, ,, ..	89	113
Expectation	79·3	105·8
	26·5	
	82·2	108·7

Plant No. 70.

Leaf-sheath and glume apex coloured, stigma coloured ..	40	59
,, ,, ,, ,, white ..	19	
,, ,, green, ,, ,, ..	41	60
Expectation	42·1	56·3
	14·2	
	43·7	57·9

Plant No. 101.

Leaf-sheath and glume apex coloured, stigma coloured ..	83	110
,, ,, ,, ,, white ..	27	
,, ,, green, ,, ,, ..	85	112
Expectation	82·2	109·7
	27·5	
	85·3	112·8

4. Leaf-sheath ratio 27 : 37, stigma 81 : 175.

Plant No. 2.

Leaf-sheath and glume apex coloured, stigma coloured ..	73	92
,, ,, ,, ,, white] ..	19	
,, ,, green, ,, ,, ..	103	122
Expectation	61·6	82·3
	20·7	
	112·7	133·4

Plant No. 10.

Leaf-sheath and glume apex coloured, stigma coloured ..	46	74
,, ,, ,, ,, white ..	28	
,, ,, green, ,, ,, ..	100	128
Expectation	55·05	73·5
	18·5	
	100·5	119·0

Conclusions.

The main conclusions to be derived from the above results are :—

1. The colours in the leaf-sheaths, glume apex and stigma of certain paddy varieties appear generally to be due to the interaction of several factors.

2. In certain cases the colour in the stigma is of a higher order than the colour in the leaf-sheath and glume apex, and is due to the presence of an extra factor not present in the leaf-sheath and glume apex.

3. Where the colour has been found to be due to the interaction of more than one factor, the simultaneous presence of all colour factors appears necessary for the production of colour at all.

Dacca,
December, 1915.

STUDIES IN INDIAN SUGARCANE, No. 2,

SUGARCANE SEEDLINGS, INCLUDING SOME CORRELATIONS BETWEEN MORPHOLOGICAL CHARACTERS AND SUCROSE IN THE JUICE.

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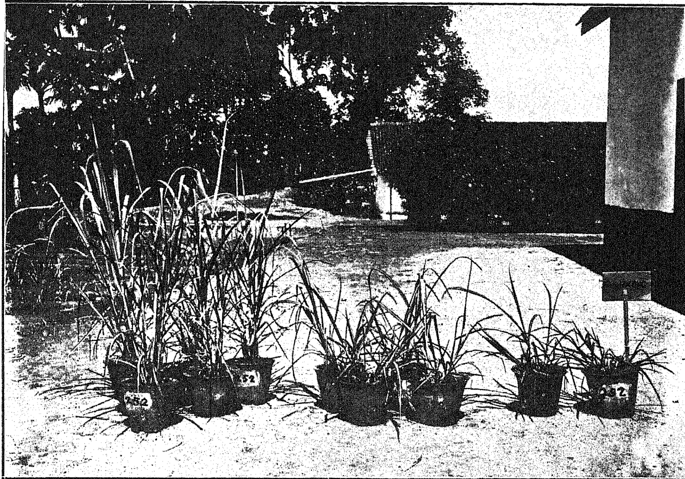
INTRODUCTION.

ONE of the most striking features in any batch of young seedlings, raised from common parents, is the variation among them in small particulars. This is true of cane seedlings as well as of other plants (Pl. I). They differ in size and shape, width of leaf and thickness of stem, colour marks in various parts and habit in general. As to the latter, the seedlings may vary from upright bushes to oblique, sprawling or prostrate. The tips of their leaves may be strict, erect, rapier, or bayonet-like in their rigidity, sharply bent or curving broadly and gracefully. The colour of their stems may be yellow, green, or white, tinged with pink, purple, red or claret, striped in various ways, shiningly smooth or thickly coated with white waxy bloom. The leaf-sheaths are less easy to describe, but here, too, we find all variations in colour between light green and dark chocolate purple, through various stages of reds and blues.

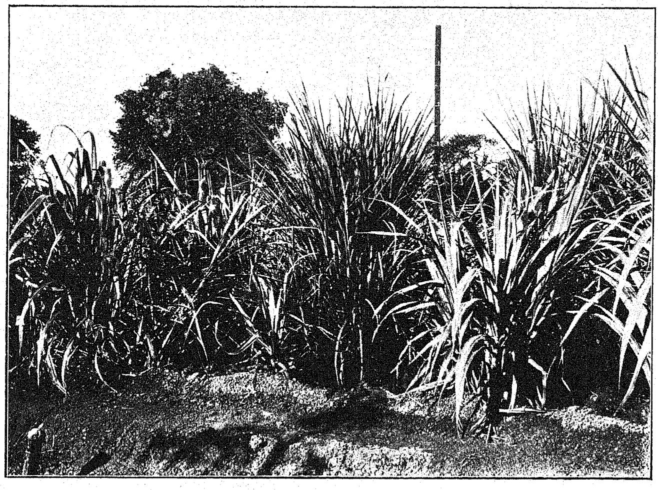
We now know, from the chemical analysis of these seedlings at harvest, that their juice also varies extraordinarily in the quantity of sugar that it contains. This is in keeping with the fact, noted in other cultivated plants, that seedlings tend to vary most in the character for which they have been selected. And the temptation is irresistible to try and correlate the various infantile characters mentioned above with the richness of the juice of the mature plant at crop time. Such an endeavour is, however, fraught with

difficulty, and yet any success in such correlation will obviously be of the greatest assistance in the early selection of new and better canes for cultivation. An enormous amount of labour is now being devoted to work of this kind, especially in the United States of America, where, among many other plants, apple trees are minutely studied in the seedling stages to try and find early indications of good new varieties. The work of cane-breeding, as compared with that of most other plants, is characterized by its extreme slowness, and any means of quickening its progress will be of great value. To grow a seedling cane from seed to maturity and to analyse its juice takes up the best part of two years. It is even then impossible to gauge its ultimate value, as it is necessary to cultivate it for several successive seasons before the natural vigour of the seedling has abated and its true growth character is understood, so that it can be put out for further trial on a crop scale in the fields. Such is the experience gained after a quarter of a century of work in this direction, and any attempt at shortening the period of testing is subject to the danger of distributing unsuitable varieties, and thus raising doubts as to the advantages to be gained by this method of improving the industry.

Comparisons are often made between the relative progress in the improvement of sugarcanes and sugar beets by the selection of seedlings. We must, however, at the outset, bear in mind that, while the beet was practically a wild plant as regards sugar content a hundred years ago, selection in the cane for sugar extends to the remotest past. It is an unfortunate fact that, despite the enormous number of cane seedlings raised, we have not made any marked progress in our search for canes with richer juice which are at the same time profitable in cultivation. The average sugar content of the canes cultivated is not appreciably greater than it was before the first seedlings were raised. The great forward strides made in the industry by the introduction of seedling canes have been rather in the direction of obtaining sound canes yielding a certain crop, one less liable to the ups and downs caused by weather and disease. The former, time-honoured, method of selection was slow and sure, but it was eminently successful, and it may take us many years before we can emulate it by producing such magnificent canes as the *Bourbon* and *Cheribon*, guaranteed to maintain their high qualities for the best part of a century. With the crop assured, however, immense advances have also been made possible in the directions of management, machinery and cultivation. In the sugar beet, the quantity of sugar in the roots has been enormously increased by a system of suitable selection. But it takes little thought to see that the conditions of the two rivals, apart from their history, are intrinsically different.



Pansahi Seedlings (1914-16), 4 months old, showing variation in habit, size, erectness, etc.



Ashy Mauritius Seedlings (1913-15), 10 months old, showing similar variations, as well as, markedly, in width of leaf.

The present contribution to the study of sugarcane seedlings in India is divided into four sections, and it has been found convenient to intercalate summaries of the work in various directions carried out on the Cane-breeding Station during its first three years. The first section deals with the material available, and contains an enumeration of the seedlings thus far raised, with notes as to the chief difficulties encountered and the means by which these have been overcome. The second discusses the differences noted in the youthful characters of the seedlings before planting out and at maturity. The next section treats of the mode of analysis adopted and the variations in the juice of the seedlings as regards sucrose content, and the last summarizes the correlations thus far studied between the characters of mature seedlings and the amount of sucrose in the juice. Because of the introduction of results of smaller detached pieces of work at various points in the course of the narrative, it has been considered advisable to append a summary of these at the end of the paper. This summary is not intended to be exhaustive, but deals chiefly with minor matters which might otherwise be lost sight of. I wish to record the fact that I have been greatly helped throughout by the enthusiasm of various members of my staff, and that the carrying out of much of the work described has fallen to their lot. I would especially mention my indebtedness to my First Assistant, M. R. Ry., T. S. Venkataraman, who has, throughout, helped me with observations, criticisms and willing work, and to Fieldman R. Thomas to whom has been entrusted the delicate work of marking down and bagging the arrows, and raising the seedlings until they were fit for planting in the field. The latter has also greatly assisted me in my observations on the variations in young seedlings. The chemical analyses, other than those done by Dr. Harrison's assistants, are the work of my Chemical Assistant, M. R. Ry., K. Krishnamurti Rao.

ENUMERATION OF SEEDLINGS.

1. Period 1911-13.

Cultivation of the sugarcane in India is extremely ancient, and in many parts of the country it has laid a firm hold on the time-honoured rotation of crops. But this cultivation has not been progressive of late years, partly no doubt owing to the fact that the *jaggery* or *gur* which is its object is not exported to any considerable extent. The Indian *gur* market is self-contained and therefore unaffected by the wave of progress which has lately swept over agriculture in the tropics. But with regard to *sugar*, the matter is very different for, while in former times India took a prominent part in the manufacture and export of this substance, the local production has not kept pace with that in other countries and, in fact, sugar manufacture in India is a negligible quantity, and increasing supplies are introduced every year to meet the growing needs of the people. The Government of India has recently devoted marked attention to this matter and, as there appears to be no intrinsic reason why India should not produce its own sugar, work has commenced in the Agricultural Department on this staple in two directions. In the first place, the local methods of manufacture need revision and, in the second, the class of canes grown is of very poor quality. The latter subject having been exhaustively discussed at the Meeting of the Board of Agriculture held at Pusa in November 1911, it was decided to found a cane-breeding station whose main line of work was to determine the possibility of raising cane seedlings, and thereby to introduce new and improved varieties suitable to the local conditions of the country. This station has been located at Coimbatore in the Madras Presidency, where the canes are known to flower profusely year by year. It was opened in April 1913, but a certain amount of preliminary work was first done in the Botanic Garden attached to the local Agricultural College.

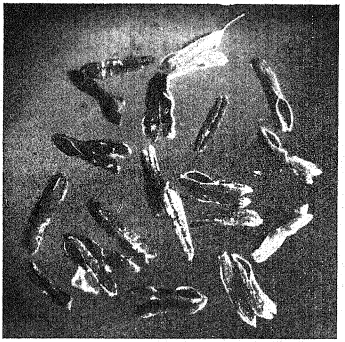
In the first seed pans laid down in the garden, many apparent cane seedlings turned out to be of those of common grasses whose seed had accidentally crept in but, early in 1912, some fourteen were obtained which proved to be seedlings of local varieties of sugarcane. The question as to whether sugarcane seedlings could be raised in India, about which there had been considerable doubt, was thus satisfactorily solved. But this meagre result, after sowing many seed

pans, led to a detailed study of the cane inflorescences. These were carefully examined for ripe seed without success. It was noted, however, that in many of the flowers the stamens were poorly developed and the anthers unopened, while inside their locules there was a mass of undeveloped pollen mother cells. In Java the method of determining whether sugarcane pollen is fully formed (and presumably fertile) has been to test it with iodine solution for the occurrence of starch. The presence of this substance indicates that the pollen grains are healthy, and a blue coloration by iodine therefore shows that the pollen is useful for fertilization. An examination of the pollen grains in the unopened locules at Coimbatore showed absence of starch, while those emerging from split locules were found to be full of this substance. The Java method was therefore replaced by the simpler observation as to whether the anther locules were open for, in that case, fully matured pollen grains were found to be invariably present, and by this means the percentage of fertile stamens in any inflorescence could easily be determined. Judging from the analogy of the inflorescence of the pepper vine (*Piper nigrum*),[1] it was thought possible that, although abundant pollen was to be found in the arrows of other canes in the same field, it was of first importance for the production of seed that good pollen and receptive stigmas should be found side by side in the same flower. The arrival of a set of arrows of a cane growing at Bangalore, in March 1912, with plenty of good pollen, was made a test case and all the arrows available of this variety were immediately sown, with the result that a further lot of 32 seedlings was readily obtained (*cf.* Plate II).

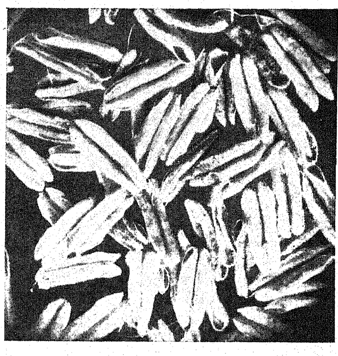
In later work, the stamens of all cane inflorescences have been examined in the following manner. The stamens are shaken out on to a clean piece of paper and preserved in a small envelope. 200 of them are taken and passed rapidly under a dissecting lens and divided into three classes :—Opened, closed, distorted. It has been found that, as in the pepper, if the anthers do not open at the time when the flowers mature, they remain permanently closed under all conditions and, once opened, they remain so permanently. They can thus be examined at any time. The percentage of open anthers in each inflorescence dealt with is entered in the following tables wherever it was obtainable. The failure of previous sporadic attempts at raising cane seedlings in India can be readily explained, in that the state of the anthers was not observed. Almost all such attempts appear to have been made in Northern India and

[1] Barber, C. A. "The Varieties of Cultivated Pepper." *Dept. Agr., Madras*, Vol. III, *Bull.* 56, 1906.

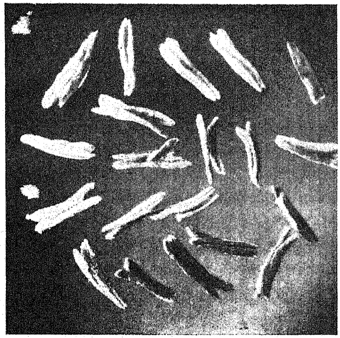
PLATE II.



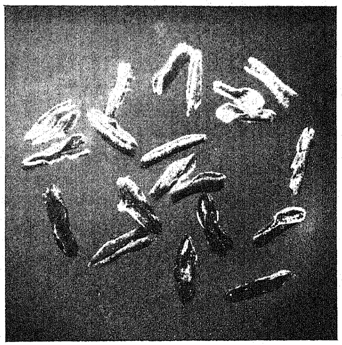
1. Cheni.



2. *Saccharum spontaneum.*



3. Vellai.

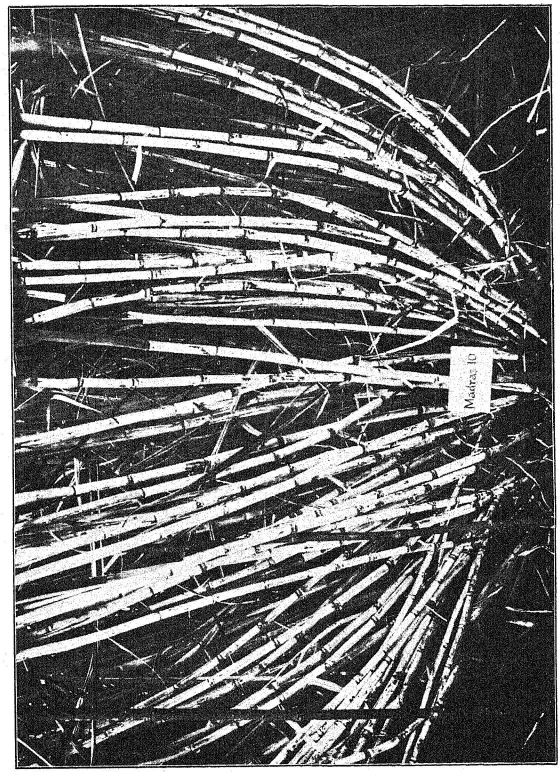


4. Red Mauritius.

Illustrating Dehiscence of Sugarcane Anthers.

In all except Vellai the anther locules are opened. In Vellai they are, as usual, closed. Magnified ten times.

PLATE III.



Madras Seedling No. 10 (Poovan parent) with 143 well developed canes at crop time.

although certain canes in this tract appear habitually to flower, an examination of the inflorescences of indigenous canes, received from North India, has shown that the anthers are completely closed and the pollen is undeveloped (Woodhouse notes that in *Khelia* grown at Sabour the anthers dehisce).[1], [2].

The following is the list of the cane seedlings obtained during the first season :—*Poovan* 9, *Namam* 2, *Kaludai Boothan* 2, *Vellai* 1, all of these being local Coimbatore canes ; *Cheni* from Bangalore 32, in all 46. The first seedlings were obtained from arrows collected in January 1912, and the poor result is now further explained in the lateness of this date in the flowering season, it being established that October-November is the best time for obtaining seed at Coimbatore, and that the fertility of the arrows steadily decreases as the season advances.

As other land was not available, these seedlings were planted out in the Botanic Garden. The ground was entirely unsuited for sugarcane growth and, accordingly, large pits, three feet cubed, were dug and filled with soil and manure ; irrigation was however only obtainable from a well of brackish water. While some of the *Cheni* seedlings suffered considerably from the salt water, most of the seedlings grew enormously under this treatment, and produced a very large number of shoots, one *Poovan* seedling having at crop time, eighteen months from sowing the seed, no less than 143 matured canes (Pl. III). But the juice of these seedlings turned out to be of quality very inferior to that of their supposed parents, and considerable doubt has been raised from this and other facts whether the parentage, other than in *Cheni*, has been correctly stated. Most of the seedlings, in fact, differed considerably from those obtained from the same canes in succeeding years.

A detailed study was made of each seedling, and photographs were taken at various stages of development ; two were sacrificed and dissected in early stages of growth. After the harvest, when the juice was analysed, they were all planted again, and have been grown on each year, in order to test the permanence of their morphological characters and the quality of their juice. At present, in October 1915, there are 38 still surviving. As noted above, the sugarcane commences to flower at Coimbatore in October, and most of the seedlings are obtained during the following two months. They are planted out in the field when about six months old and are ready for harvesting and analysis after another twelve months, or eighteen months from sowing. It

[1] Woodhouse and Basu. The Distinguishing Characters of Sugarcanes cultivated at Sabour, *Mem. Dept., Agr. Ind., Botanical Series*, VII, 2, Apl. 1915.

[2] A large number of arrows were received from North India in 1915, and in these occasionally a few (1—4%) of the anthers were open, April 1916.

has been found convenient to designate the seedlings obtained during any particular season by the years of sowing and of final chemical analysis and, accordingly, the first year's seedlings are called those of 1911-13. Notes as to the character of their juice will be found in a following section.

2. PERIOD 1912-14.

The Cane-breeding Station was sanctioned in October 1912 and a full-time officer placed in charge of it, with a suitable establishment. Profiting by the previous year's experience, it was found possible to raise a comparatively large number of seedlings in the season then commencing, more in fact than could be dealt with at maturity. Of the 10,000 to 20,000 seedlings obtained, some 2,000 were selected, from as many different parents as possible, and grown on. These were raised in the Botanic Garden, but they were planted out in the newly acquired farm at Chettipalayam, a village about a mile and a half from the College. Besides searching the neighbouring country for varieties of flowering canes with open anthers, arrows were obtained from various parts of the Madras Presidency, as well as, through the kindness of Dr. Coleman, from Bangalore, as this place has also proved to be an excellent centre for cane-flowering.

A careful note has been taken of canes flowering in recent tours through sugarcane tracts. Taking India as a whole, the flowering of the sugarcane appears to decrease as we proceed north-west. In Madras and Mysore it is a common occurrence, but in the former it is more abundant in the drier, western than in the moister, eastern parts. Flowering is not uncommon among the canes growing at Nagpur, Jubbulpore and other parts of the Central Provinces, and extends in a north easterly direction as far as Assam, but with a diminishing intensity. In Bihar, certain kinds such as *Khari* (and the introduced *Saretha*) flower habitually, and in certain years large stretches of canes have been noted as flowering in the eastern parts of the United Provinces. Passing thence to the north west, however, cane flowering becomes rare or entirely ceases. The following varieties have been noted by Mr. Woodhouse[1] as flowering in exceptional years at Sabour in Bihar :—*Chynia, Khelia, Maneria, Pansahi* and *Shakarchynia.* A large number of the varieties of North Indian canes collected on the Cane-breeding Station at Coimbatore have now flowered, often without the anthers being open.

NOTE.—It is of some interest to compare, with this brief statement, the flowering of the wild Saccharums observed during the last few years. *Saccharum spontaneum* is widely distri-

[1] Woodhouse and Basu. The Distinguishing Characters of Sugarcanes cultivated at Sabour, *Mem. Dept. Agr. Ind., Botanical Series*, VII, 2, Apl. 1915.

buted over all parts of India and everywhere flowers profusely. It has been successfully crossed with three North Indian canes in the Cane-breeding Station. *Saccharum arundinaceum* appears to be at home in Assam, where it flowers freely, the hill section of the Assam railway revealing a mass of its showy spikes all along its banks. This species probably needs the humid Assam climate for perfection of growth, for it soon becomes rare in a westerly direction. It is recorded as flowering in the Botanic Garden at Saharanpur,[1] but the specimens planted in the grounds of the Lyallpur Agricultural College have not flowered during the eight years since they were introduced. In South India *Saccharum arundinaceum* is frequently planted, and is the usual hedge for *betel* (*Piper Betle*) plantations. It is thus very common at Coimbatore but, although allowed to grow for several years, it has never been known to flower. It flowers, however, in the moister north-eastern part of the Madras Presidency and is reported to have been in flower at Tanjore. *Saccharum Munja* is not much in evidence in Assam and Bengal, if it occurs there but, passing along the submontane tract to the west, it soon replaces *Saccharum arundinaceum* and extends, flowering profusely, from Bihar to the Punjab. It has been introduced to the Cane-breeding Station and grows and flowers fairly freely, but the flowers are poor and nothing like so handsome as in the north. The stamens are, however, fairly well developed. *Saccharum Narenga* is, again, at home in Assam, where vast tracts on the northern side of the Brahmaputra and the Shillong hills are covered by it, often to the exclusion of other vegetation. It appears to pass along the foot of the Himalayas to the north-west. A chance arrow collected in North Bihar has given many seedlings in the Cane-breeding Station, and it grows and flowers freely there with fully developed stamens. It has been successfully crossed with *Vellai*, a thick introduced cane. In conclusion, there seems to be a certain amount of confusion in the classification of Indian Saccharums. In the *Flora of British India*, *Saccharum Munja* and *S. arundinaceum* are placed together under the latter specific name. This arrangement is followed in the Calcutta Herbareum. From my knowledge of the growth of these plants and their divergent distribution, I cannot but feel that they are entirely separate, but this conclusion is chiefly based on their leaf and stem characters. In a recent tour in Assam and Bengal, I have, moreover, come across a number of puzzling forms which lead me to suspect that still other wild Saccharums may occur there as yet unseparated or undescribed. None of them were, however, in flower at the time of my visit.

As many of the seed pans during the 1912-14 period also showed a good growth of various grasses, the whole question of the early treatment of seedlings was overhauled and a great number of methods were tried, both as to the most suitable medium in which to grow them (from sand, red and black earth, leaf-mould, manure, to pounded peat from the Nilgiris and various mixtures of these substances) and the manner in which the medium should be treated, so as to destroy any grass or weed seeds that they might contain. The following is the method (copied from Java) in use at the time of writing. Old horse manure is obtained, finely pounded, watered and exposed to the air. All seeds in it soon germinate and are pulled out as they appear, and, after a time, the manure, cleared of its weeds, is stored in pits for further use. The arrows are collected when the first florets begin to fall or are blown off by the wind, and are kept in paper packages for a week or ten days for the seeds to mature,

[1] Hole. On Some Indian Forest Grasses and their Œcology. *Indian Forest Memoirs*, *For. Bot. Ser.* I, 1, 1911. Pl. XXII.

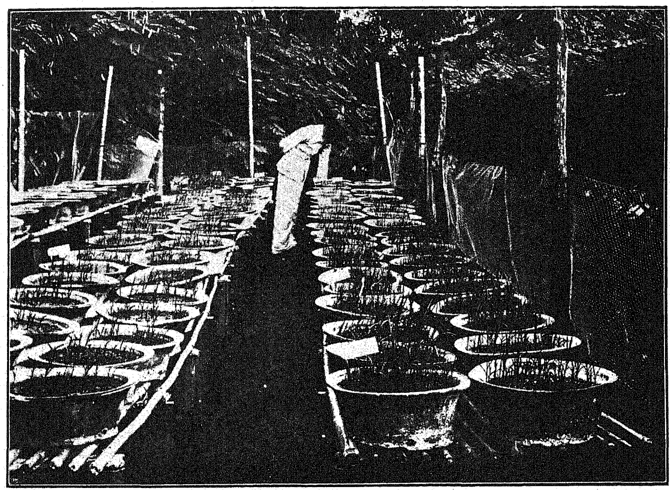
after which they are ready for sowing. Equal parts of the prepared horse manure and river sand are well mixed and placed in shallow pans, 12″ across and 3″ deep. The fluffy inflorescence of the cane is broken up and plastered upon the surface of the mixture in the pan and thoroughly watered through a rose watering can. After this it is found that the flowers and flower stalks form a wefted mass disturbed neither by wind nor by heavy rain. It was sought at first to protect the young seedlings from the torrential rains which fall at this time of the year (October-November), but it was soon found that, owing to the porous nature of the mixture of sand and horse dung, they suffered not the slightest injury. It was found, however, essential to keep them fully exposed so as to have as much sunlight as possible, as the least shade rendered them liable to damping off or yellowing. In this manner, if there is any seed in the arrows, it is usual to look with a lens for the first spot of green in the germinating embryo within three or four days. But experience has shown us that sometimes the seed does not germinate so quickly, the seed in some pans continuing to germinate for a month after sowing. When the seedlings grow thickly, it is advisable to prick them out at greater distances in similar pans in which a certain quantity of soil and leaf-mould is added, and this is done when they are about two inches high. Where, however, there is plenty of room, they are left in the pans until they are some three to six inches high, as each transfer appears to check their growth. They are then transferred to pots (*cf.* Pl. IV). The soil in these is carefully prepared as follows. Fine red earth is brought from certain fields about seven miles away, and this is mixed with equal parts of ordinary earth, cattle manure and leaf-mould. The pots are 9″ across and a foot high and one seedling is placed in each. They are left in these pots until they are planted out in the field. Watering in both the pans and the pots is a considerable item of expense and needs constant care. The pans are, in the absence of rain, watered with a can five times a day, and the pots should be watered twice daily. Improvements are constantly being made in this matter, but one of the latest is to dig broad trenches in which half a dozen rows of pots may be sunk and where they may be irrigated all together. The sides of the sunk pots are protected from the air and, when thus arranged, they need not be irrigated more than, say, twice a week, and the cost of the operation is nominal. This, with five thousand pots, is a matter of considerable saving of expense. But there are drawbacks in this method which will be referred to when the further treatment of the seedling is described (*cf.* p. 149).

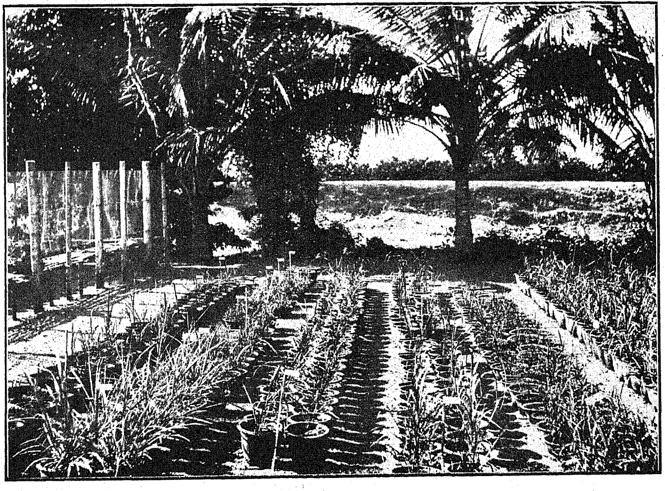
One of the greatest obstacles in the raising of the seedlings at Coimbatore is the fact that the canes arrow during the north-east monsoon, at a time when

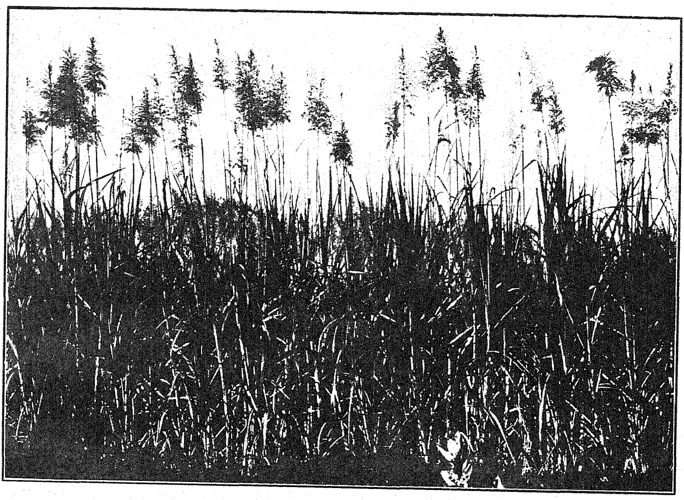
DESCRIPTION OF PLATE IV.

Sugarcane seedlings in pans and pots. In the latter, the larger seedlings in the left foreground are of *Saccharum arundinaceum*, and are somewhat older than the rest as this species flowers early. They are from arrows received from Anakapalle, in the north of the Madras Presidency.

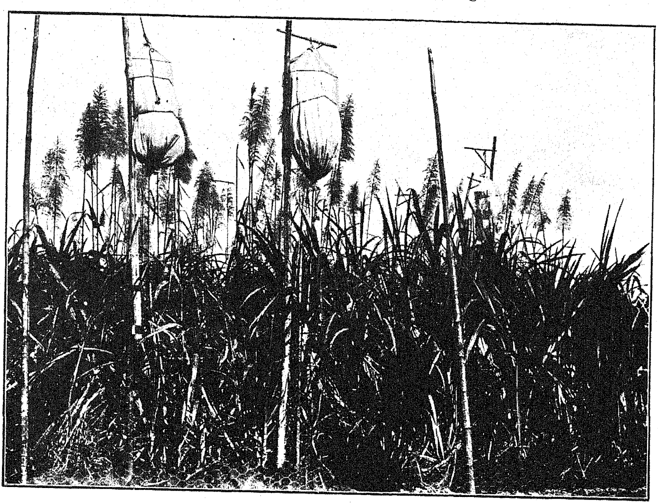
PLATE IV.







Madras Seedling No. 1017, arrowing.



Method of selfing or crossing arrows. Crosses are effected by blowing in pollen each day and immediately covering up again.

two-thirds of the annual rainfall descends. These rains are often heavy and accompanied by strong winds, so that many arrows are broken or the pollen is destroyed by thorough wetting. Sometimes, for a week or fortnight on end, no collecting can be done, and this, considering the short time during which fertile arrows can be obtained, is a serious disadvantage. Many of the arrows during the earlier years were obtained at places from five to ten miles from the farm, and in order to ensure their daily inspection and bring the matured arrows in safely, a great deal of travelling under trying conditions was necessary.

The protection of the flowers from cross-pollination was instituted during the 1912 season, but it was found impossible properly to supervise the distant cages, and this supervision was only effective in cages over the few arrows in the Botanic Garden. The cages are made of iron rods or, preferably, strips of bamboo covered with fine, close muslin, as the pollen is capable of passing through the finest meshes. They hang over the inflorescences from a tall gallows-like support, and can be raised or lowered at will. The whole apparatus is a close adaptation of that used in the Java cane-breeding work (Pl. V). Because of heavy winds, it has often been found necessary to place an additional upright bamboo or even two and tie the swinging cage to them. The operation requires considerable care, because it has been found that even the slightest permanent bend of the long, fragile inflorescence stalk destroys the fertility of the whole arrow, and this is by no means an infrequent occurrence in the heavy weather at Coimbatore at this time of year. From past experience, a general impression has been gathered that the very fact of caging is prejudicial to the full development of the inflorescence, although large numbers of seedlings are sometimes obtained in this way. Caging must be done before the arrow emerges from its enveloping sheath, for the stamens have been found sometimes to open before this emergence occurs. Enclosing the inflorescence thus takes place some time before the introduction of foreign pollen. The cane varieties are closely watched about this time of year and the approach of flowering is foretold some time before it occurs by the elongation of the terminal internodes and the presence of small leaves at the top of a cane shoot. The cane is then said to be in "short-blade" and its record is carefully gone over to see in what way the inflorescence may be used. If, on emergence, the flowers are found to contain few or no open anthers, crossing may be attempted, but we have at present no criterion by which to tell whether the female organs are fully formed, as we have in the male. Our only guide is the successful rearing of the seedlings in the pan after sowing. To illustrate the need for daily inspection of the cages, one fact may be mentioned here. On several

occasions it has been noticed that rats have gained access to the cages, have pulled together the fluffy inflorescence to form a nest, and have even introduced pieces of foreign arrows into the cages—an undesired attempt at cross-pollination on their part! Half-inch wire netting has to be added when rats are abundant.

In the following table a summary is arranged, showing the origin and fate of the seedlings raised during the period 1912-14, with notes on the percentage of open anthers, and on the possible male parentage of the seedlings, where the flowers were unprotected from foreign pollination. It may be noted that comparatively few of the inflorescences were protected, and that then only the female parent is known with certainty; batches of seedlings from unprotected arrows are termed "General Collection," as contrasted with "Crossed" or "Selfed" lots.

A study of the contents of the table brings to light certain interesting facts regarding the germinating power and vitality of the different classes of seedlings. The local canes grown by ryots round Coimbatore are five in number, and these produced the great bulk of the seedlings of the period. These are thick (probably exotic ?) canes which have been established for a number of years:—*Chittan*, *Karun*, *Kaludai Boothan*, *Poovan* and *Vellai*. From their detailed morphological study, it seems probable that the first three are closely related to one another, there being some ground for supposing that *Chittan*, a striped cane, is the oldest and that *Karun* (claret) and *Kaludai Boothan* (green with blush of pink) have at some time arisen as sports from it. *Karun* and *Chittan* produced a large number of seedlings. They are hardy canes of moderate value, and, in the absence of the better ones, a good number of their seedlings were planted out. *Kaludai Boothan*, on the other hand, was disappointing in germination (although it is interesting to note that in the succeeding year matters were reversed) and, further, its seedlings were unfortunate in that they were planted out in inferior land. *Poovan* is a glaucous green cane with rather poor juice, much appreciated as an eating cane, and is fairly widely cultivated. It proved difficult to raise seedlings from it and they were different in character from those obtained in the first year, thus supporting the idea that the latter were in some way abnormal. No seedlings were obtained from *Vellai* arrows. This is by far the best local cane but, as will be seen later, the development of pollen is very precarious (*cf.* also Pl. II). *Naanal*, although a South Indian cane, is not grown near Coimbatore and is very different from the rest. It appears to be an indigenous or *desi* cane somewhat similar to the *Chin* group, although a good deal thicker than most of them, is very hardy and has fair juice. The arrows were obtained from

Enumeration of 1912-14 *Seedlings.*

Variety	Locality	Anthesis, % open	Pans sown	Germination	Planted out	Serial Numbers	Analysed at harvest	Selected*	Remarks as to probable Parentage
Karun ...	Villages round Coimbatore.	42 % ?	55	3944	504	819—1322	397	75	Anthesis determined from an old arrow, therefore probably too low—Selfed or possibly crossed by neighbouring Kaludai Boothan or Chittan. (These varieties are usually grown intermingled in the fields.)
Kaludai Boothan.	Do	71 %	11	714	264	1520—1783	61	8	Selfed or possibly crossed by neighbouring Karun or Chittan.
Chittan ...	Do	76—78 %	23+	2761	769	50—818	509	75	Selfed or possibly crossed by neighbouring Kaludai Boothan or Karun.
Poovan ...	Do	75 %	Sown in bed.	50	27	1785—1811	14	4	Poovan flowers at a slightly different time from other local canes (above)—Probably selfed, as no other arrows noted at the time in the fields.
Naanal ...	Karur, in Coimbatore district.	2·5 % ?	23+	267	197	1323—1519	149	18	Naanal is usually grown pure in the fields and the other local varieties (above) were not present. The arrows were collected at Karur some distance away and most stamens dropped in transit: of those remaining 2·5 % were open. From a study of the seedlings it is possible that crosses with a wild Saccharum occur.
Cheni ...	Mysore ...	9—10 % ?	16	50	36	2082—2117	15	6	Cheni is usually grown pure in Mysore. Only old stamens were available, therefore percentage open probably too low. Chances of a cross remote.
Java ...	Do	43—48 %	6	3000	17	1919—1935	2	1	Old arrows gave 43-48% open anthers, a figure probably too low because the first flowers usually have more open anthers. Selfed or possibly crossed by B208 or Pattapatti.
B208 ...	Do	2·5—87 %	19+	52	40	1936—1975	7	3	Little information available. Only old flowers available. No information as to other arrows near.
Seema-like Mauritius.	Samalkota, Madras Pres.	66 %	4	35	27	1892—1918	3	0	No information regarding arrows in the field. Received by post.
Saretha ...	Botanic garden, Coimbatore.	86—98 %	3	166	80	1812—1891	51	25	Muslin-bagged, therefore selfed. All from one arrow.
Chin ...	Do	40 % ?	1	3	3	1976—1978	3	2	Upper stamens 40 % open anthers, lower twisted and distorted. Perhaps selfed as no other arrows very near, but *Saccharum spontaneum* flowering. Seedlings remarkably like the next lot.
Chin × ... *Saccharum spontaneum*	Do Do	0 % 95 %	4	22	18	1980—1997	13	9	Chin anthers closed. Muslin-bagged previous to emergence and afterwards dusted daily for six days with *Saccharum spontaneum* pollen. Apparently a genuine cross.
Shakarchynia. × *Saccharum spontaneum.*	Do Do	0 % 95 %	2	89	84	1998—2081	75	64	As above. Apparently a genuine cross.
Totals...	......	......	167	11153	2032	50—2081	1299	290	Besides the above series a large number of seedlings were raised from *Saccharum spontaneum* and *Saccharum Narenga.*

* The selection was for high sucrose content or botanical interest. The former applies to the thick canes, the latter to the indigenous varieties—Naanal, Cheni, Saretha, Chin, and the crosses.

Karur, some fifty miles distant, and there is reason to suppose that some of the seedlings were abnormal. Seven of them showed marked resemblance to *Saccharum spontaneum* and are spoken of as the "spontaneum class" of *Naanal* seedlings.

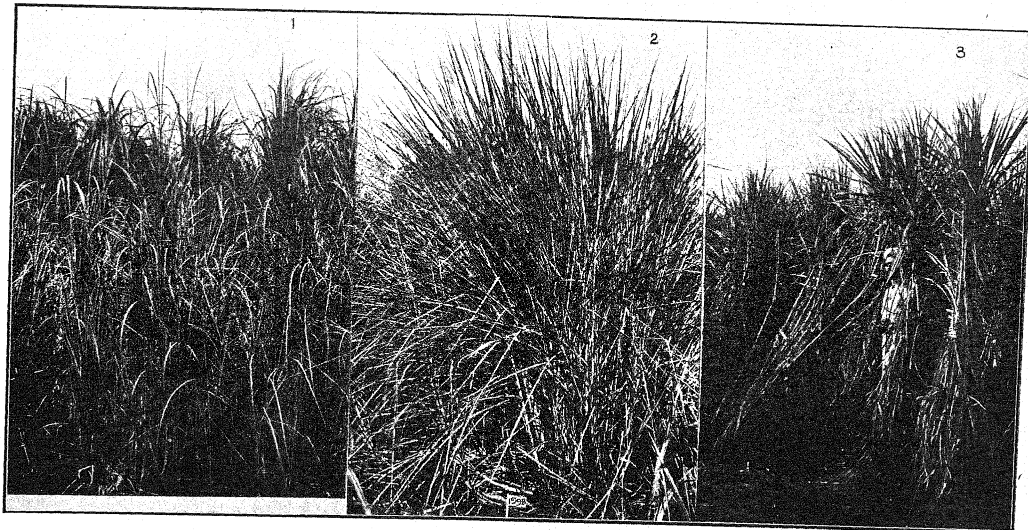
Of the arrows obtained from Bangalore, "*Java*," a valuable cane of unknown origin, produced an enormous number of seedlings, an average of at least 500 per pan. But, in spite of the greatest attention, including special treatment and early pricking out, the seedlings soon turned brownish yellow and died in great numbers. This delicacy continued after potting up and, of the whole lot of over 3,000 seedlings, it was only possible to place 16 in pots and to grow two to maturity so that they could be analysed. The results of the sowing of *B. 208* arrows, from which much was, expected was, on the other hand, disappointing because of the poor germination, added to great mortality when planted out. *Cheni*, an indigenous Mysore cane, somewhat resembling *Naanal*, also gave a poor result.

Seedlings raised in the Botanic Garden, from indigenous North-Indian canes introduced in the previous year, had both parents known. *Saretha* was selfed and gave good results. It is a valuable cane in its tract (Meerut and Aligarh) and is a constant flowerer. The crosses between *Chin* and *Shakarchynia* and the wild *Saccharum spontaneum* were also healthy and vigorous throughout their growth. It was unfortunate that crosses could not be effected between these North Indian canes and the thicker, exotic ones, but they did not flower at the same time. The pollen in *Chin* and *Shakarchynia* was undeveloped, and the crosses effected had their use, in that the perfect fertility between *Saccharum spontaneum* and cultivated canes was demonstrated, and the character of seedlings with *Saccharum spontaneum* parentage was established (Pl. VI).

All the seedlings obtained during this season were carefully studied at crop time, according to a detailed plan left behind by the author when going on leave, and, as will be seen in the last section, these descriptions form the basis of the correlations studied between the morphological characters of the seedlings and the quality of their juice.

3. Period 1913-15.

The canes growing on the newly founded Cane-breeding Station, planted about May, did not flower to any great extent at the end of 1913, and outside arrows were again chiefly used to obtain seedlings during this season. Great help was, however, afforded by a free flowering of the canes growing in the wet



Shakarchynia x *Saccharum spontaneum*. Fig. 1. *Saccharum spontaneum* in the foreground, with extremely narrow leaves, curving gracefully. Fig. 3. Shakarchynia, the female parent, a Bihar cane with strict, erect-tipped leaves. Fig. 1. (background) and Fig. 2. seedlings obtained by crossing these two. In the former the leaftips are curved like those of *Saccharum spontaneum*, and in the latter they are erect and strict, as in Shakarchynia.

PLATE VII

DESCRIPTION OF PLATE VII.

Saline plot. The labels are placed to the left of rows of different varieties of cane. The land is saline and the canes have been irrigated with saline water. The three figures are one continuous series, proceeding from left to right and from above downwards. The measuring sticks show the extent of overlapping. The top figure gives indigenous Indian canes and the centre of the middle figure thick canes. Some Madras seedlings are shown in the lower figure. The varieties are, in order, *Cheni*, *Naanal*, *Teru*, *Katha*, *Chin*, *Saretha*, *Karan*, *Chittan*, *Kaludai Boothan*, *Poovan*, J. 36, B. 208, Putli Khajee M.2, M.12, M.25, M.45, M.1017, *Hullu Kabbu*.


Cheni
Kaaral
Teru
Katha
Chin
Sareth
Karun
Chittu
K. 5
Poovu
J 36
B 208
Purli
M 2
M 12
M 25
M 45
M 107
Hulla

(tank-irrigated) land on the Central Farm near by. The villages around were again ransacked, arrows were forwarded by post from the Madras Farms at Samalkota and Taliparamba, and, as in the previous season, a large number were obtained from Bangalore. Over 20,000 seedlings were raised and, from these, some 2,400 were selected and planted out. A considerable number of varieties of canes had meantime been collected from various parts of India and these formed the "varietal plots" in the Cane-breeding Station. But their growth was at first extremely poor, and few if any of them showed any tendency to form arrows. This led to a study of the reasons for their failure, as it appeared to be almost as difficult to grow North Indian canes at Coimbatore as to reverse the process and grow thick canes in the fields in North India.

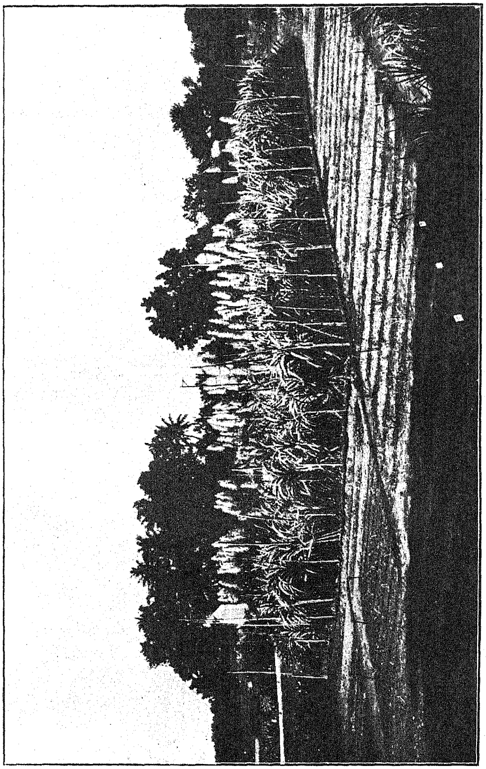
The piece of land selected for the Cane-breeding Station was a block of "garden land" (well irrigated), within easy reach of the College laboratory. The more usual cane land, black clay, irrigated by water from tanks and termed "wet-land," was avoided, as it was considered unsuitable for the growth of seedlings intended for North India. Upon examination, the soil on the farm was found to be slightly saline, and it was recognised before purchase that it would need a certain amount of treatment before sugarcanes would grow there normally. Isolated plots of canes were seen growing near, and the ryots agreed that it was suitable land, but pointed out, in their homely language, that "it was not yet accustomed" to sugarcane. This of course did not interfere with the excellent growth of the seedlings, for these were planted in pits with specially prepared earth and manure. An analysis of the wells on the station showed that five of them had brackish water and irrigation had therefore to be confined to the one sweet-water well, on which a pump and oil engine were erected capable of dealing with the four or five acres intended for sugarcane cultivation each year. The cause of the poor growth of the varieties planted during the first year was not far to seek, in that they were planted out of season and, of necessity, on land which had been irrigated for years by brackish water, and which there was no time to prepare (*cf.* Pl. XXVII for a photograph of canes growing in this land; these were thick canes), and a series of tests were instituted to note the effect of this water on the different varieties of cane introduced. The results of this experiment are extremely interesting, showing that different canes vary enormously in their capacity of resistance to saline soil and water, some growing strongly and rapidly while others die out completely (Pl. VII). The experiment is being continued yearly, as an alkaline or "saline plot," on untreated land irrigated by brackish water, into which the varieties are introduced in turn. The land intended for cane growing in each season is heavily covered with tank silt and a crop of juar

(*Andropogon Sorghum*) planted. A green-dressing plant (usually *Dolichos Lablab*, the field bean), is then planted and dug in, and wide drains are made at short distances apart. This treatment has had very beneficial effects and, although some super-sensitive varieties still appear to suffer, the North Indian canes, at any rate, have now been fully acclimatized and are growing extremely vigorously.

The study of the causes of arrowing in the cane has also led to fruitful results. There are two cane-planting seasons in the neighbourhood of Coimbatore, one in February-March and one in July-August or even later. The former is in vogue on garden land irrigated by wells and the latter on wet lands under tanks. The period for planting in wet lands is limited by the filling of the tanks, but the ryots cultivating garden lands are free to choose their own time. They have selected February-March for several reasons. The canes planted then are still young when the fierce winds of the south-west monsoon sweep over the land in June to August, and are well established and off the ground when the heayv wet weather comes with the north-east monsoon in October-November. Incidentally, they also secure a suitable ripening season for the canes, in the dry cool months of December and January followed by the dry hot months of February and March, the hottest part of the year at Coimbatore. From a special study of each field from which arrows were obtained in the neighbourhood, it soon became evident that canes planted in February-March do not usually flower, while those planted at any time between August and November do so in the following October-November, if allowed to remain in the ground. In the wet land generally, then, the canes are more likely to flower, and this has been found to be the case even when they are planted as early as April-May. As a result of this study, an " arrowing plot " was put down on the station as an experiment with certain varieties in November 1913. The result was eminently satisfactory and the plot was a mass of arrows in the following October (Pl. VIII). At the same time, through the kindness of Mr. Wood, a number of North Indian and other cane varieties were planted in the wet land on the Central Farm and most of these also flowered. Altogether, some twelve North Indian canes bore arrows, some of them for the first time on record. Unfortunately, in most of these, the stamens proved to be obstinately closed, but it is hoped that the way is being opened for obtaining the desired cross between a hardy North Indian indigenous cane and a richer exotic one, if they can be induced to flower at the same time.[1]

[1] During the 1915 season, 71 varieties of cane flowered on the Cane-breeding Station, half of which were North Indian canes.

PLATE VIII.



Arrowing plot, October 1914.

Enumeration of 1913-15 *Seedlings.*

1. One parent known, or selfed.

Variety	Locality	Anthesis, % open	Pans sown	Germination	Planted out	Serial Numbers	Analysed at harvest	Selected *	Remarks on Parentage
Karun	Villages round Coimbatore.	40—50 %	41	170	100	2200—2299	44	...	Probably mostly selfed. Practically pure Karun in the field, some arrows caged.
Kaludai Boothan...	Do	80 %	30	3,000	400	2400—2799	121	21	Probably mostly selfed, but possible crosses with Poovan, of which a number of arrows were present.
Chittan ...	Do	80 %	30	120	100	2300—2399	45	5	Probably mostly selfed. The bulk of the field consisted of Chittan, with a sprinkling of Poovan and Kaludai Boothan.
Poovan... ...	Do	90—91 %	10	125	100	3300—3399	16	2	Probably mostly selfed. One lot caged and selfed. Karun was flowering in the field also.
Red Mauritius ...	Central Farm, Coimbatore.	96 %	1	1,000	7	4293—4299	...	...	Caged and selfed.
Green Sport of Striped Mauritius	Do	45 %	16	110	100	4300—4399	45	17	No record of other varieties flowering.
Red Sport of Striped Mauritius.	Do	75 %	8	20	16	4400—4416	13	4	No record of other varieties flowering.
Fiji C.	Do	97·5 %	6	130	81	4418—4498	13	2	The bulk of these were caged and selfed.
Fiji B.	Do	92·5 %	1	10	2	4416—4417	...	...	Caged and selfed.
Ashy Mauritius ...	Central Farm and Mysore.	68—83 %	5	155	100	4500—4599	46	17	50 seedlings caged and selfed
Striped Mauritius	Do	67—87 %	18	380	200	4000—4199	96	27	In the fields with these varieties all were flowering near together. The seedlings are selfed or casual crosses
Java	Mysore ...	46—76 %	15	9,000	400	3400—3799	169	79	
B. 208	Do	67—90 %	14	1,850	200	3800—3999	103	44	100 seedlings caged and selfed
White Mauritius	Do	60—77 %	1	530	93	4200—4292	22	6	One-third caged and selfed. No record regarding other varieties flowering near.
Total ...			196	16,610	1,899	2200—2799 and 3300—4599	733	224	

* The standard of selection was raised this year to 18% sucrose in the juice and over, in all excepting Vellai × *Saccharum Narenga* and Vellai × Naanal Seedlings 1464, 1354, 1428.

Enumeration of 1913-15 *Seedlings.*

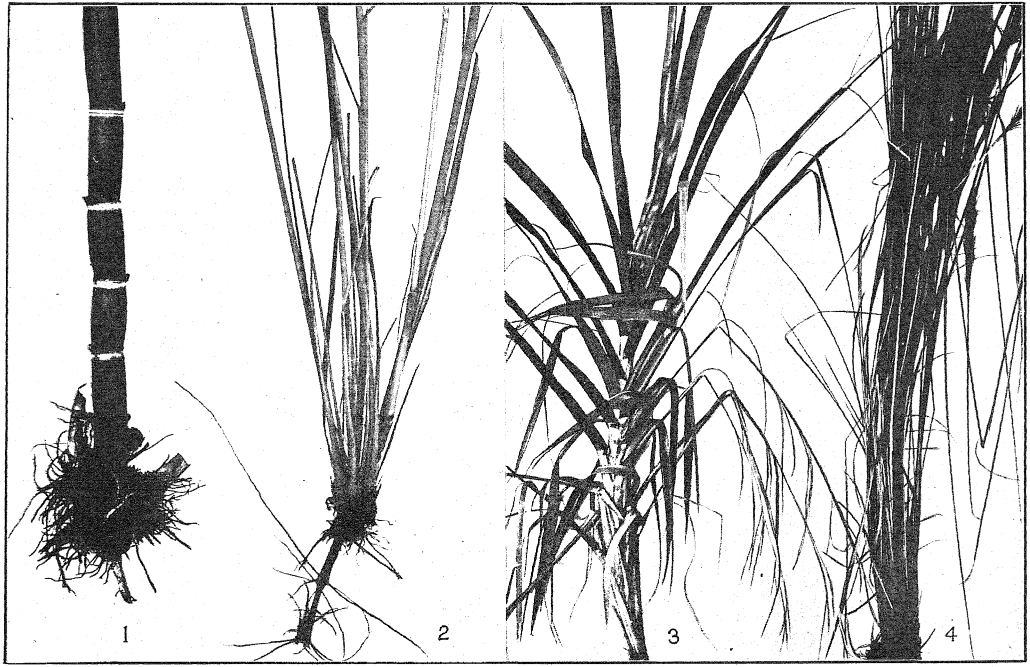
2. Attempted crosses.

Varieties crossed	Locality	Anthesis, % open	Pans sown	Germination	Planted out	Serial Numbers	Analysed at harvest	Selected	Remarks as to Parentage
Vellai × ... Chittan ♂ ...	Central Farm and villages around. Villages round Coimbatore.	4—63 % 80 %	4	35	16	3200—3215	1	--	Probably crosses among selfed seedlings.
Vellai × ... Fiji C ♂ ...	Central Farm Central Farm	0 % 60—97 %	4	110	95	3100—3194	56	10	Crosses.
Vellai × ... Karun ♂ ...	Central Farm Villages round Coimbatore.	1 % 80 %	2	40	32	3000—3031	20	8	Probable crosses.
Vellai × ... Ashy Mauritius ♂ ...	Central Farm and villages. Central Farm	17—50 % 83 %	7	150	100	2900—2999	58	16	Probably crosses among selfed seedlings.
Vellai × ... Striped Mauritius	Central Farm and villages. Central Farm	4—63 % 87 %	4	70	66	3032—3097	33	7	Probably crosses among selfed seedlings.
Vellai × ... *Sacch. Narenga* ♂	Villages round Coimbatore. Cane-breeding Station.	? 90 %	4	200	100	2800—2899	87	3	Judging by the characters of the seedlings, apparently all crosses.
Vellai × ... M. 1464 ♂ ...	Villages round Coimbatore. Cane-breeding Station	5 % 96 %	5	20	16	3248—3263	12	1	Judging by the characters of the seedlings, apparently all crosses.
Vellai × ... M. 1354 ♂ ...	Central Farm Cane-breeding Station.	1 % 90 %	1	50	32	3216—3247	22	1	Judging by the characters of the seedlings, apparently all crosses.
Vellai × ... M. 1428 ♂ ...	Central Farm and villages. Cane-breeding Station.	3·5 % 97·5 %	3	60	32	3264—3295	18	3	Judging by the characters of the seedlings, apparently all crosses.
Saretha × *Saccharum spontaneum.*	Cane breeding Station.	0 % 90 %	1	40	30	Not numbered.	23	3	A cross.
Total ...	... ...	...	35	775	519	2800—3295	307	52	

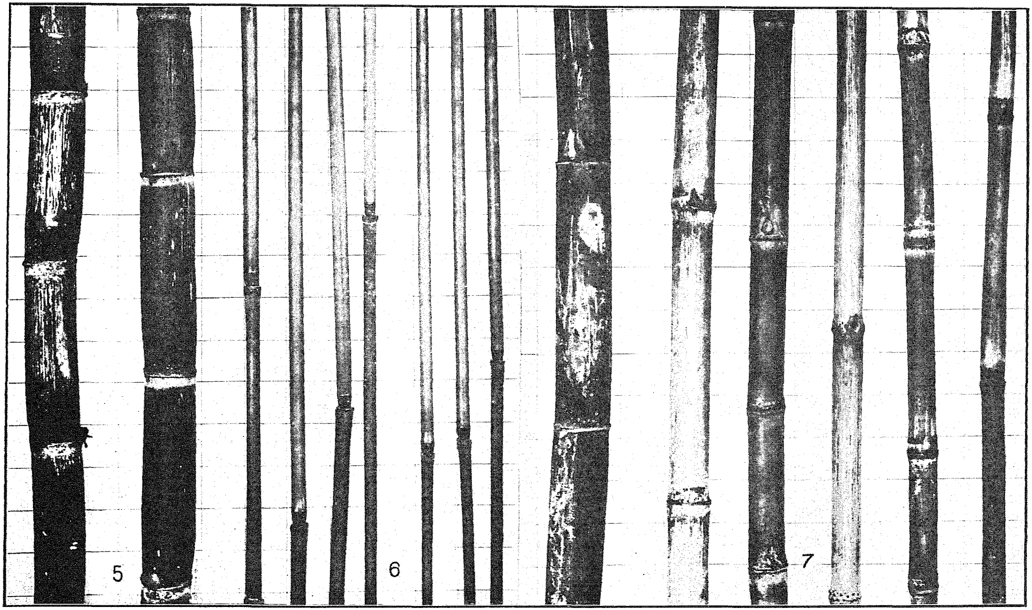
Besides the above, a large number of Madras seedlings with *Saccharum spontaneum* blood in them and the *Saccharum spontaneum* class of Naanal seedlings were selfed and crossed in various ways. About 700 of these were planted out but time was not available for their full study and they were not numbered in the collection.

Vellai x *Saccharum Narenga* (1913-15). Crosses obtained. Fig. 4. Young seedlings flowering when 10 months old. Fig. 5. The same plot at crop time. These flowered again when 22 months old.

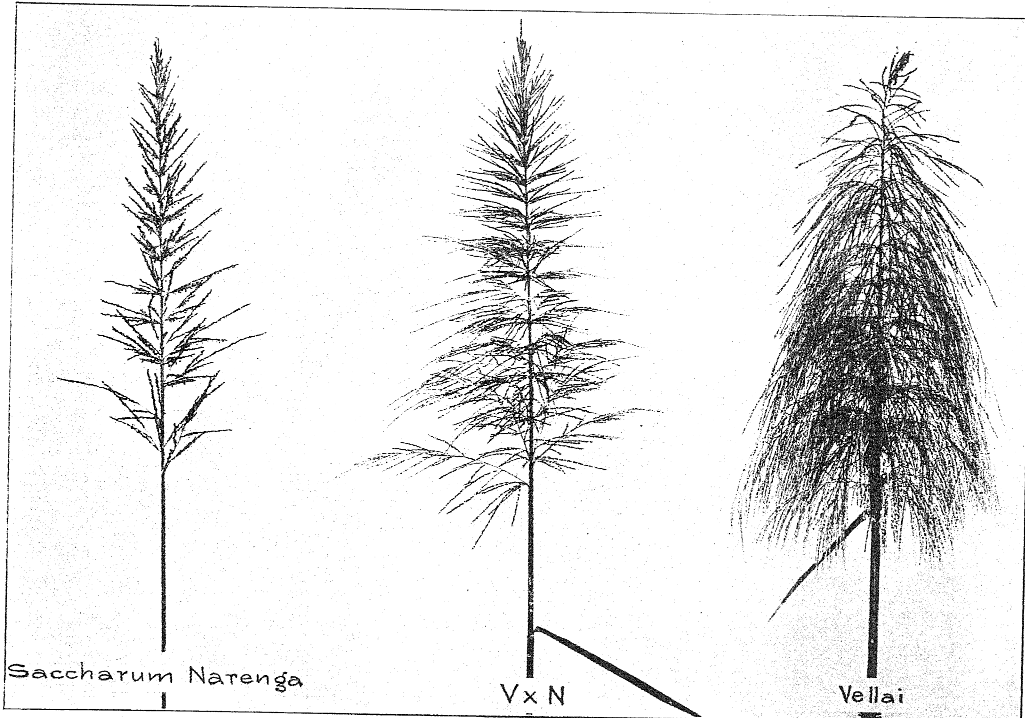
Vellai x *Saccharum Narenga* (1913-15). Crosses obtained. Fig. 4. Young seedlings flowering when 10 months old. Fig. 5. The same plot at crop time. These flowered again when 22 months old.



Vellai x *Saccharum Narenga* (1913-15). Stems and leaves in parents. Fig. 1. Rooted cane of Vellai. Fig. 2. *Saccharum Narenga:* all the canes are flowering stalks. Fig. 3. Foliage of Vellai. Fig. 4. Foliage of *Saccharum Narenga.*



Vellai x *Saccharum Narenga* (1913-15). Canes of parents & seedlings. Fig. 5. Two Vellai canes. Figs. 6. *Saccharum Narenga* "canes"
Fig. 7. A selection of the canes of the resulting crosses, from the thickest to the thinnest, one average cane from each of six seedlings.



Vellai x *Saccharum Narenga.* Arrows of the parents and of a typical cross.

In the table giving details of the seedlings obtained in 1913-15, several features of interest are observable. In the first place, it may be noted that there is a total absence of seedlings with parentage of indigenous Indian canes. This was by no means of choice but, as has already been pointed out, hardly any of these canes flowered during the year, on being transferred, out of season from the Botanic garden to the Cane-breeding Station. Secondly, there is a greatly extended range of parents, especially in the direction of those of better quality, more recently introduced into India. Thirdly, taking advantage of the fact that *Vellai* frequently has a very poor development of open anthers, a serious attempt was made to dust its arrows with pollen from other varieties, an experiment which was rendered possible by a large number of arrows on the *Vellai* plants growing in the wet land on the Central Farm.

These *Vellai* arrows on examination gave percentages of opened anthers from 0 to 63 (*cf.* Pl. II), and the probable proportion of crosses obtained is judged accordingly in the remarks column. Where the pollinating plant was a thick, exotic cane, it is less easy to state whether crosses have been obtained. Those used were *Chittan, Karun, Fiji C, Ashy Mauritius* and *Striped Mauritius* and all of these canes are more or less similar in general character to *Vellai*. In the cases of *Vellai* pollinated by *Saccharum Narenga* and by Madras Seedlings 1464, 1428 and 1354 (parents *Naanal*), however, there is no manner of doubt, from a casual glance, that all or almost all are genuine crosses. The differences between the parents are very great, and the seedlings obtained are half way in measurements of leaf and stem and in the character of their inflorescences, in general habit and appearance, and in sucrose in the juice. These morphological characters of parents, seedlings and crosses are illustrated in a series of figures in Plates IX to XI. And this fact also renders it at least probable that many of the first named seedlings, those obtained after dusting *Vellai* arrows with pollen of thick canes, are also crosses, and therefore likely to be of value in cultivation.[1]

The usual collection was made of arrows of local canes from neighbouring villages, and over a hundred pans were sown with these. An analysis of the results rather reverses the conclusions which might have been drawn from a study of the 1912-14 seedlings. In the latter case, while masses of seedlings were readily obtained from *Chittan* and *Karun* arrows, those of *Kaludai Boothan* gave poorer results. But in 1913-15 the *Kaludai Boothan* arrows were extremely fertile, yielding at least 100 seedlings per pan, while *Chittan* and *Karun*, with 70 pans, gave only 300 seedlings together. This reversal was not

[1] NOTE.—This is rendered more probable in that later attempts at raising uncrossed *Vellai* seedlings have failed—Apl. 1916.

unexpected for, as has been stated above, these varieties are closely related, and this could have hardly been the case with so marked a difference in fertility. There is no apparent reason for these seasonal divergences, and the only explanation available is that the arrows might have been of different age or influenced by the state of weather when pollination took place.

Of the arrows received from Bangalore, those of *Ashy Mauritius* and *Striped Mauritius* produced fair results and *White Mauritius* good ones. It is reported that a large number of seedlings have been obtained at Bangalore from the latter cane, yielding a very high percentage of sucrose in the juice, and it is all the more to be regretted that this variety is said to have died out there during the season. A number of arrows of *Java* and *B 208* were received from Bangalore and these proved very fertile, *B 208* giving well over 100 seedlings and *Java* the surprising number of 700, per pan. But the lack of vitality proved to be so great that only 200 seedlings could be planted from *B 208* and 400 from *Java*.

To the same category of canes with fertile arrows but with seedlings unable to withstand the earlier stages, *Red Mauritius* appears to belong. From this variety 1,000 seedlings were raised in one pan, of which only 7 could be planted out. The other canes flowering in the Central Farm were *Striped Mauritius, Red Sport of Striped Mauritius, Fiji C* and *Fiji B*: these were not very fertile, but most of the seedlings raised were subsequently planted out in the field.

Besides *Java* and *Red Mauritius*, two other varieties have been found of which it is difficult to obtain seedlings, namely *Poovan* and *Fiji C*. But the course of events appears to be different from *Java* in these canes, for the seedlings grew fairly well until planted out in the field, then became light coloured and weak, and few have succeeded well enough in the plots to be worth analysing (*cf.* Pl. XIII). The *Red Mauritius* and *Fiji C* seedlings were from selfed arrows, while *Poovan*, although growing mixed with the other local canes, flowers at a slightly different time and its seedlings are also probably usually selfed.

Besides the seedlings mentioned in the table, a large number were obtained by selfing and crossing such of the Madras seedlings of 1912-14 as flowered, but these were chiefly such as had *Saccharum spontaneum* blood in them and their agricultural value was so poor that they have not been included in the list. The crosses between the North Indian canes *Shakarchynia* and *Chin*, and *Saccharum spontaneum*, in the 1912-14 period, flowered early and abundantly, as seems to be the case with all seedlings with the blood of wild Saccharums

in them, but few had any open anthers, and some of these seedlings were accordingly crossed with one parent, *Saccharum spontaneum*, the only plant with open anthers at the time. No time has unfortunately been available for the study of this interesting series. The spontaneum-like class of seedlings from *Naanal* were, however, provided with abundant open anthers and several of these were selfed as well as crossed by *Saccharum spontaneum*. It is unfortunate that these interesting seedlings flower at a time when no thick canes have yet arrived at this stage for, by selecting the best of them, the way might be opened for obtaining a new set of canes presumably of a very hardy nature. A further small set of seedlings was also obtained in 1913-15 by crossing *Saretha*, another North Indian cane, with *Saccharum spontaneum*.

4. Period 1914-16.

During the first two years, considerable changes were made in the treatment of seedlings after removal from their pots. When the seedlings have been growing for about six months they are transferred from them and planted out in the field. In the first period, 1911-13, as has been stated. the few seedlings obtained were treated very generously, three-foot pits being dug and filled with prepared earth and manure. The conditions in which they were planted made it advisable to treat them as "pot plants," and enough material was provided in the pits for their growth to maturity. Even in these pits the plants were attacked by white ants and certain seedlings were killed, but on the whole their growth was remarkably rapid and healthy, especially in those derived from local parentage. The 1912-14 seedlings, planted on better land and irrigated with less saline water, were put into two-foot pits, in order, if possible, to reduce the great vigour of the seedlings and bring them more into line with ordinary cane plants. The growth was still luxuriant and, in succeeding years, the exceptional treatment of the seedlings was gradually reduced until, in 1914-16, half of them were planted in one-foot holes and the rest in trenches. Concurrently with this, the treatment of the seedlings grown a second year from cuttings was gradually improved, for it was found that the growth of the seedlings when first propagated vegetatively was distinctly precarious, and a certain number of them died out. This attempt at equalizing had also another reason. The analysis of the *Cheni* seedlings in their second year showed a very marked increase in sucrose in the juice, and it was thought that this might be due to the excessive vigour of the seedlings in the large pits. Sufficient evidence has not yet been accumulated on this subject but, on studying any batch of seedlings and their analyses, the general impression makes itself felt that there is an inverse

relation between vigour and richness in the juice, a similar tendency having been noted in indigo and cinchona and doubtless other plants.[1] The whole question is, however, complicated by the fact that the land at Chettipalayam is still largely influenced by having been irrigated by brackish water wells for thirty years and more, and is not of equal suitability for sugarcane growth in different parts.

It has been noted in the description of the seedlings of previous years that those of some parents lacked vitality. *Java* and *Red Mauritius* (and perhaps *B 208*) were characterized by great fertility of arrows, and produced enormous numbers of seedlings in the pans, which, however, soon died in spite of every care. In *Poovan* and *Fiji C*, on the other hand, the seedlings lived until planting out time and then gradually failed, so that the plot in which they were planted became more and more empty towards harvest. It was argued that such varieties would form suitable parents if crossed with hardier kinds, and that, if the seedlings obtained grew with vigour, there would be *primâ facie* evidence that true crosses had been obtained. This line was accordingly taken during the 1914-16 season and a large number of crosses were attempted, chiefly with North Indian canes. Unfortunately, the latter had few open anthers and had to be used as mothers and this particular experiment had to be postponed.

Owing to the great quantity of *Java* arrows obtainable at Bangalore, it was decided to obtain pollen from the canes growing there, for dusting the local arrows at Coimbatore. This led us to a study of the pollen and its vitality. Unexpected difficulties were, however, encountered, in that sugarcane pollen proved very hard to germinate in any of the media usually employed for this purpose, and it was of course necessary to germinate it in order to test its keeping qualities. Some success was ultimately obtained by crushing the stigmas of wild plants flowering at the time, and germinations seem to succeed especially with solutions prepared from the flowers of the prickly pear and *Portia* tree (*Thespesia populnea*). Pollen of *Saccharum spontaneum* appeared to retain its vitality much longer than expected, and after 14 days some of the grains still germinated in these solutions. The sending of the pollen by post would appear to be feasible in small gelatine capsules which are easily procurable and can be readily transmitted without any chance of the pollen drying up.

As a large number of arrows were obtained from Bangalore, it was considered advisable also to test the vitality of cane seed, usually regarded as

[1] Barber, C. A., Some Difficulties in the Improvement of Indian Sugarcanes. *Annals of Applied Biology*, vol. 1, nos. 3 & 4, Jan. 1915, p. 214.

extremely short-lived. A collection was made of seeds of Madras seedlings 2 and 6, *B 208, Java, Striped Mauritius* and *Saretha*, from the 14th December 1914 to the 5th January 1915, and equal quantities of powdered arrows were sown on the first of each succeeding month. The results shown in the table are interesting, as it is evident that, with proper care, cane seed retains its vitality for a considerable time.

Vitality of Sugarcane Seed.

Variety	Date of Collection	Germination	Feb. 1	Mar. 1	Apl. 1	June 1	July 1	Aug. 1	Remarks
Madras No. 2	9th Dec. 1914.	500	500	300	200	100	20	0	Equal quantities of pounded arrow were sown in the first five. Some seed remained capable of germination for seven months. The seed of Saretha survived the longest and that of B 208 had least vitality.
,, ,, 6	15th Dec. 1914.	500	500	300	200	100	20	0	
Saretha ...	14th Dec. 1914.	500	500	500	300	200	40	0	
Java	4th Jan. 1915.	500	500	300	100	50	0	0	
B 208	5th Jan. 1915.	500	500	300	Less than 100	12	5	0	
Striped Mauritius.	Do. ...	200	200	100	50	12	0	0	A less quantity of arrow sown.

A study of the table containing details of the seedlings raised during the 1914 arrowing season shows a very considerable change in the selection of parents. In the first place, it was assumed from previous experience that the quality of the parents' juice is largely transmitted to the offspring, and an effort was made to obtain as many seedlings as possible of the best canes growing in the various farms. Over 9,000 seedlings were obtained from *B 208, Java, Striped Mauritius, Ashy Mauritius* and *Fiji C* and, of these, more than 1,600 have been selected for planting out. The local kinds, *Karun, Chittan* and *Kaludai Boothan* were comparatively neglected, and no collections were made from villages around, as these canes were flowering in the arrowing plots on the station. The results from these arrows were, however, very poor as regards germination and only 50 seedlings were planted out. On the other hand, advantage was taken of the flowering of North Indian canes, and a very large number of seedlings were obtained of *Saretha*. Over 1,100 seedlings derived from North Indian canes were planted out, chiefly of *Saretha, Chin* and *Pansahi*. One hundred seedlings were also planted out of Madras Selfed Seedling No. 2 (*Kaludai Boothan* parent), for the special study of the depressed habit which characterizes this seedling, as well as most of those obtained from indigenous canes in India.

Enumeration of 1914-16 *Seedlings.*

1.—One parent known or selfed.

Variety	Locality	Anthesis, % open	Pans sown	Germination	Planted out	Serial Numbers	Remarks as to Parentage
Striped Mauritius	Mysore ...	10—64%	30	2013	540	5201—5500 5601—5800 6181—6200 6581—6600	B. 208, Java and Striped Mauritius were flowering together and these seedlings are either selfed or possible crosses.
Java ...	Do	92%	19	4000	380	6201—6580	
B. 208 ...	Do	87—98%	32	2770	500	6701—7200	
Ashy Mauritius	Do	48%	14	210	150	7201—7350	Mostly selfed but possibly crossed with Striped Mauritius.
Fiji C. ...	Central Farm ...	?	4	75	50	4851—4900	The arrows were rather isolated. A selfed arrow had 96% anthers open, but when sown gave no seedlings. The seeds were covered by fungus hyphæ.
Vellai ...	Cane-breeding Station.	41—68%	5	4	4	6646—6649	Selfed.
Kaludai Boothan	Do	83%	6	25	23	6678—6700	Kaludai Boothan, Chittan, and Karun flowered together. The seedlings are either selfed or possible crosses.
Chittan ...	Do	69%	6	40	25	6601—6625	
Saretha ...	Central Farm & Cane-breeding Station.	62—81%	15	5400	700	5900—6100 7501—8000	200 were selfed and the rest had no other canes flowering near. Some Chin arrows were open but distant. Probably selfed seedlings.
Chin ...	Do	16—84%	12	330	200	5001—5200	100 were selfed. The rest were probably selfed (*cf.* Saretha).
Cheni ..	Central Farm ...	88%	2	86	60	4901—4960	Selfed.
Pansahi ...	Do	5—18%	6	116	100	4601—4700	6 selfed seedlings and the rest uncaged. M. 2 and M. 6 were flowering freely near by and Chynia further off—therefore selfed or possible crosses with these.
Pansahi ? ...	Do	6—11%	7	16	11	5561—5565 5571—5576	6 selfed seedlings and 5 uncaged. The ? is due to a mistake in labelling and it is not likely that these seedlings will be kept.
Chynia ...	Do	23% ?	4	40+	40	4961—5000	M. 2 and M. 6 flowering freely near by and Pansahi further off (*cf.* Pansahi).
M. 2 (Kaludai Boothan Parent).	Do	92%	3	200	100	7401—7500	Selfed.

Enumeration of 1914-16 seedlings.

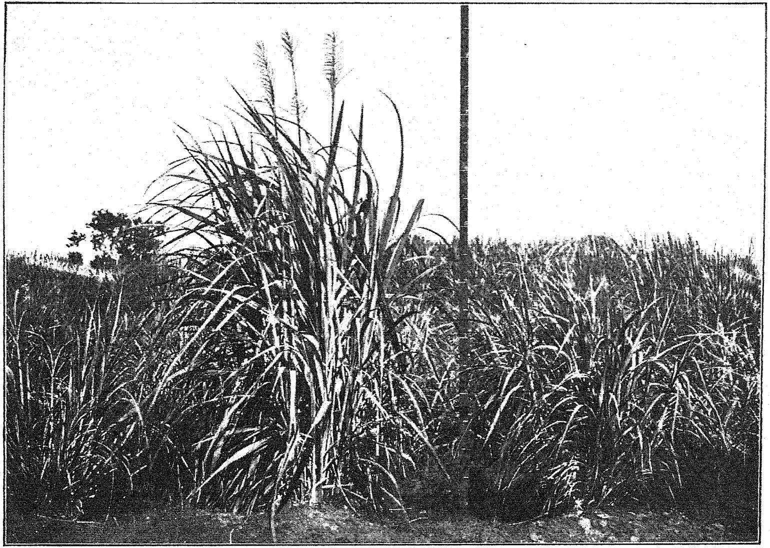
2.—ATTEMPTED CROSSES.

Varieties crossed*	Locality	Anthesis, % open	Pans sown	Germination	Planted out	Serial Numbers	REMARKS AS TO PARENTAGE
B. 208 × Saretha	Mysore Cane-breeding Station.	95% 50% ?	3	20	19	5501—5519	Selfed or crossed, but little indication of the latter in the seedlings.
B. 208 × Striped Mauritius ?	Mysore	?	4	70	50	7351—7400	Owing to a mistake in labelling it is doubtful what this is.
Vellai × Kaludai Boothan	Cane-breeding Station.	30—69% 80%	2	30	27	6651—6677	As in B. 208 × Saretha.
Vellai × Chittan	Do	14—80% 68%	2	15	14	6631—6644	Do.
Vellai × M. 6	Cane-breeding Station. Central Farm	36—65% 97%	2	1	1	5549	Do.
Java × Chin	Mysore Central Farm	92% 76% ?	4	900	70	6101—6170	Do.
Saretha × B. 208	Cane-breeding Station. Mysore	45% 87%	2	55	50	5801—5850	Do.
Saretha × Java	Cane-breeding Station. Mysore	81% 92%	1	150	50	5851—5900	Do.
Chin × Java	Central Farm Mysore	47% 92%	1	12	10	6171—6180	Do.
Chin × B. 208	Central Farm Mysore	71% 87%	2	40	10	5531—5540	Do.
Cheni × Java	Central Farm Mysore	72% 92%	2	15	10	5521—5530	Do.
Pansahi × Fiji C.	Central Farm	3—8% 91—98%	3	180	150	4701—4850	Possibly crossed in that Pansahi selfed only produced 6 seedlings, but little trace in the seedlings of Fiji C influence.
Pansahi × B. 208	Central Farm Mysore	5% 87%	4	3	2	5599—5600	As in B. 208 × Saretha.
Pansahi × Java	Central Farm Mysore	5—26% 92%	6	8	5	5591—5595	Do.
Pansahi ? × Kaludai Boothan	Central Farm Cane-breeding Station.	5% 82%	2	15	12	5541—5546 5551—5556	Do.
Pansahi ? × Ashy Mauritius	Central Farm	4% 67%	2	3	2	5589—5590	Do.
Pansahi ? × Fiji C.	Do	5% 90%	2	6	5	5581—5585	Do.
Chynia × Fiji C.	Do	13% 73%	2	2	2	5559—5560	Do.
Chynia × Java	Central Farm Mysore	34% 92%	1	3	2	5569—5570	Do.
Chynia × B. 208	Central Farm Mysore	16% 87%	1	2	2	5579—5580	Do.
Chynia × Chittan	Central Farm Cane-breeding Station.	7% 69%	2	5	5	6626—6630	Do.

* In all clases the second named parent is the male.

A very large number of crosses were attempted between indigenous canes and thick exotic ones but, on the whole, with very poor results. Pollen was freely sent to Bangalore, where an officer was deputed for three months, to get if possible crosses by *Saretha* and *Chin* on to *Java* and *B 208*, while *Vellai* was crossed, as in the previous year, on the station at Coimbatore. Owing to the poor development of the stamens in most indigenous canes, pollen was brought from the good varieties at Bangalore and dusted on *Saretha*, *Chin*, *Pansahi*, *Cheni* and *Chynia*. But, taking the seedlings obtained after these operations as a whole, there was very little evidence, at planting out, of the influence of the male parent. This strengthens the impression noted below that, if fertile pollen is present in any inflorescence, it is largely prepotent over any foreign pollen introduced and that, in any general collection of arrows in the field, most of the seedlings are selfed, in spite of other varieties flowering at the same time in the vicinity.

PLATE XII.



Chin plot (1914-16). Occasional seedlings are met with, which stand out from the rest in some particular. In the figure, one seedling is much larger and more erect, has broader leaves and is flowering earlier than the rest.

VARIATION IN MORPHOLOGICAL CHARACTERS.

The first few seedlings, obtained before starting the Cane-breeding Station, were reared in the Botanic Garden. Their reputed parentage was four local Coimbatore canes and *Cheni* from Mysore. It was noted that the seedlings in each batch differed a good deal among themselves, while those of *Cheni* stood apart as a class separate from the rest. During the next two flowering seasons much time was spent in touring throughout the cane-growing tracts of India and, although occasional notes were made as to differences in the young seedlings, there was no opportunity for going thoroughly into the matter. During the 1914 flowering season, the whole of the 1914-16 seedlings, 3,400 in number, were submitted to a more or less detailed examination before planting out, and have been classified and put into the ground according to the differences noted. The present section, in which some of these variations are discussed, is largely based on the observations made during this examination.

Most of the seedlings fall under the term "General Collection," by which is indicated that no special means were taken to prevent the arrows from being pollinated by neighbouring ones which happened to be protruding at the same time. Some hundreds were "selfed," that is to say, protected from foreign pollen by fine muslin placed over them before emergence. In studying these two classes of seedlings, it has been noted, however, that there seems to be practically no difference between them, and the opinion has been gradually formed that, in the field, where open anthers are present, the great bulk of the general collection are in reality selfed seedlings. It is only in cases where the mother arrows have practically no open anthers that the seedlings have shown, by their intermediate characters, that crosses have been obtained. The descriptions enumerated below have been drawn indiscriminately from batches of selfed seedlings and those obtained from the general collections of arrows.

Vigour and Size.

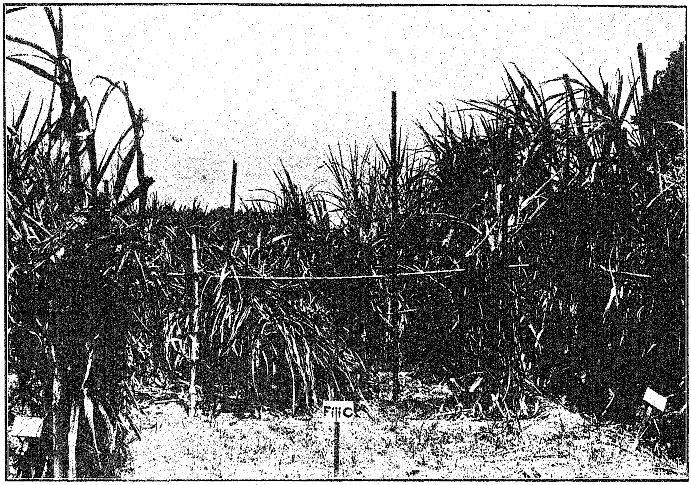
It is obvious, at a glance, that the seedlings of any one batch differ greatly in size and vigour (Plates I & XII). This is not likely to be altogether due to their environment, as care is taken to treat all in exactly the same manner,

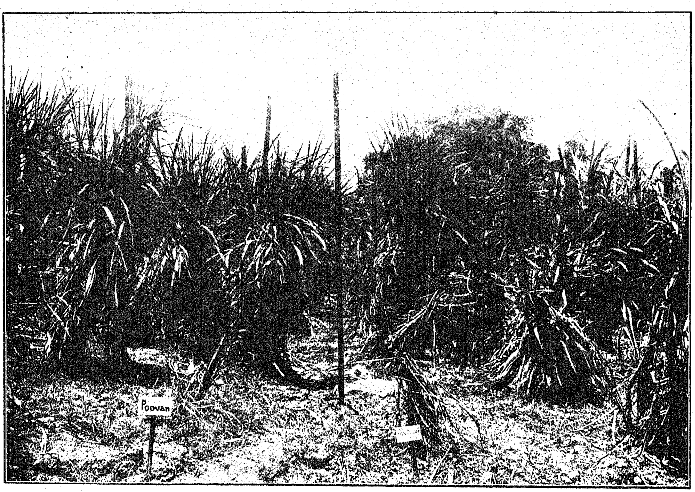
in the soil mixture used, the size of the pots and their watering and exposure to the sun and their ultimate treatment when planted out. It is not easy to determine whether the poor growth of seedlings is transmitted, for the further growth of poor, stunted seedlings, although perhaps of scientific interest, would hardly be defensible, considering the main object of the Cane-breeding Station, and such plants as are obviously inferior in these respects have been uniformly rejected when planting out. The only information as to the future growth of the seedlings which show signs of weakness during their first year's growth is to be obtained from a study of the first (1911-13) seedlings, all of which have been grown on for several years. In these the fate of the weak seedlings is clearly traceable, in that most of them have gradually become weaker and died out one by one, although some of them have shown that they possess very fair juice; and this appears to justify the method of rigorous selection, practised in the young seedlings of any year and also when they are chosen for vegetative reproduction in the second year.

Attention has already been drawn to the fact that the seedlings of some varieties, while coming up in large numbers, quickly die out, thus indicating feebleness in their early stages. Such are *Java*, *Red Mauritius* and possibly *B 208*. In other canes, notably *Poovan* and *Fiji C*, the lack of vigour appears later and, after planting out, the plots of these varieties soon present a sorry appearance, many of the seedlings becoming weak and sickly, and comparatively few surviving so as to be capable of analysis at crop time (Plate XIII). From present appearances, the *Red Mauritius* seedlings suffer all along, but we have had too few seedlings of that variety to be able to state the case definitely.[1] In contrast with these feeble seedling varieties, *Saretha* and *Pansahi* seem to have good germination and healthy seedlings, few of which succumb. Of the 5,000 *Saretha* seedlings obtained in the 1914-16 period, some 1,200 are being grown on, 700 in the plots and the rest in a piece of waste land where they seem to be perfectly at home. There have been hardly any deaths, and there is little doubt that practically the whole 5,000 could have been raised if it had been desirable to do so.

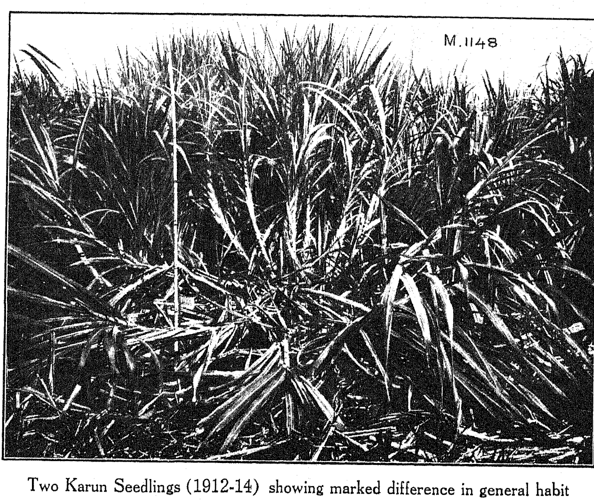
Karun, *Chittan* and *Kaludai Boothan* seedlings are also easy to raise. But this is especially so with genuine crosses, which have thus far in all known cases been exceptionally vigorous. It must be mentioned, however, that most of our crosses, thus far obtained with certainty, have been between North Indian canes and wild parents, but the thick *Vellai* × *Saccharum Narenga* seedlings are very similar as regards luxuriance.

[1] The seedlings of *Red Mauritius* in 1915-17 appear to the more healthy.





Seedling of Poovan & Fiji C plots at crop time. The better grown plants on either side and in the background belong to neighbouring plots.



Two Karun Seedlings (1912-14) showing marked difference in general habit at maturity.

The vigour of any seedling is judged by early rapid growth, ultimate size and, at maturity, by the number of canes and shoots developed, and the total weight of the above ground parts at crop time. In a considerable number of cases it has been noted that seedlings standing out from the rest because of their great growth, have a comparatively low sucrose percentage in the juice. Excessive vigour in a seedling otherwise than a cross is therefore not altogether a desirable character.

General Habit.

There is often marked variability in the habit of seedlings of common parentage (Plates XII & XIV). We shall note elsewhere (pp. 148—149) that the appearance of a variety in the field, often difficult to describe in technical language, is one of the most trustworthy and permanent characters whereby we can distinguish closely allied cane varieties.[1] Height and width of bushes, thickness of canes, width of leaves and the way in which the leaves curve are individual habit characters of value, but we refer here to the combination of several of these and other factors, which gives the whole a definite appearance in the field. (*Cf.* p. 148.)

When the *Saretha* (selfed) seedlings of 1912-14 were nearly ready for reaping, an attempt was made to classify them, using as a guide their general resemblance to other types of North Indian canes; and, on analysing the juice at crop time, it was found that, while the individuals in these classes gave more or less uniform results, the classes differed widely from one another in general sucrose and glucose averages. They were grouped as follows:—

1. *Mungo-Nargori*-like plants. Short erect bushes with moderately narrow leaves curving broadly at their ends, reminding of *Mungo*, some becoming more or less bunched at the ends of the shoots, the short thin stems being clothed with dead leaves, reminding of *Nargori*.

2. Small plants with the bushy habit of *Mungo* but with narrower leaves and some of the outer branches spreading or prostrate.

3. *Sarauti*-like plants. Dense, thick, short bushes with the ends of the leaves strict or curved.

4. *Saretha*-like plants. Tall, erect, with stems rather widely separated, the outer canes spreading or obliquely ascending, leaves moderately broad and more or less curved.

[1] This method of classification has been successfully used by Woodhouse and Basu in their description of the Sabour sugarcanes.—*Ibid.*

5. *Shakarchynia*-like plants. Usually tall, erect, strict, with the outer shoots only slightly ascending, stems closely packed, leaf tips not curving, strict.

6. Plants with oblique branches, reminding of birds' nests, or prostrate.

It will be seen, from the figures on Plates XV and XVA that most of these differ very widely from the parent *Saretha*, which is an interesting fact, considering that all the seedlings were obtained from one selfed arrow. The following are some of the characters revealed in their final examination at crop time :—

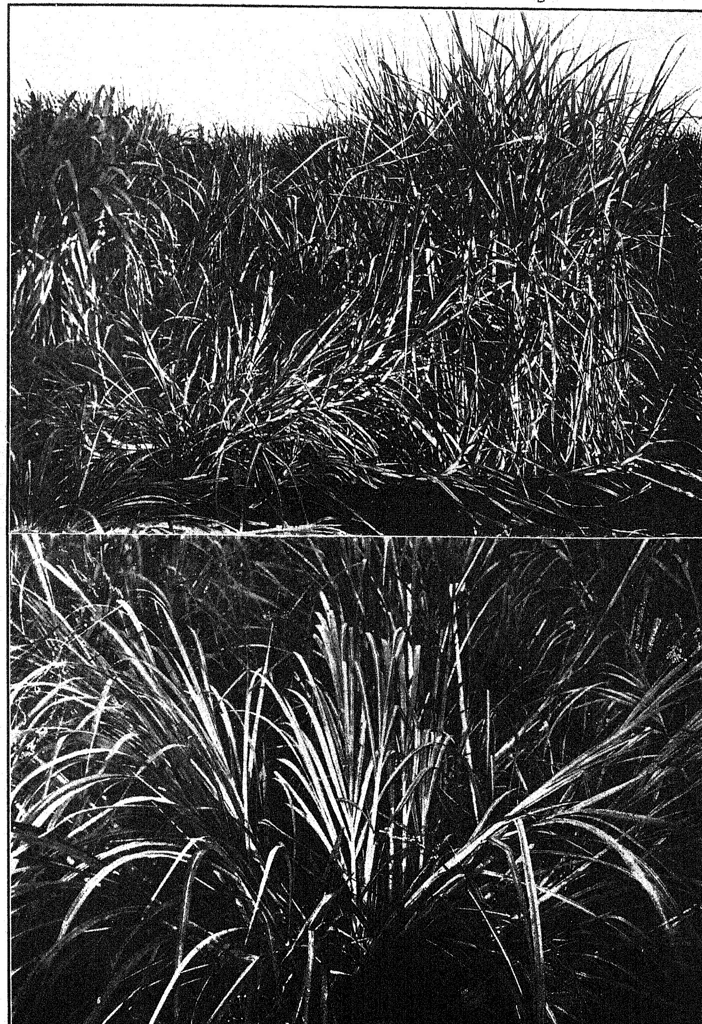
Habit classes	Number of seedlings	Leaf width in inches	Total weight in lb.	Sucrose % in juice	Glucose % in juice
1. *Mungo-Nargori*	17	1·06	58	14·64	0·19
2. Small oblique *Mungo* ...	5	0·84	29	15·82	0·14
3. *Sarauti*	2	1·16	69	12·30	0·14
4. *Saretha*	8	1·44	122	14·80	0·12
5. *Shakarchynia*	2	1·27	83	12·34	0·10
6. Oblique or prostrate ...	6	0·94	45	13·58	0·29

From the table it would appear that this line, of separating out seedlings according to habit, may be a profitable one, and it is interesting to note that, taking all the characters together, the class most resembling the parent is the best. It has, however, been found very difficult to distinguish classes of seedlings before they are near maturity.

In the *Naanal* seedlings of the season 1912-14, seven were easily picked out quite early, differing widely from the rest, in that they had extremely narrow leaves, grew very vigorously and took on a strong resemblance to the wild *Saccharum spontaneum*, although obviously not belonging to that species. The rest of the seedlings, with broader leaves, were subdivided according to their erectness and bushiness, characters which change a good deal during the early stages of a seedling (Plates XVI and XXIV). The following were the results of the final examination at crop time :—

Habit classes	Number of seedlings	Leaf width in inches	Total weight in lb.	Sucrose % in juice	Glucose % in juice
1. *Saccharum spontaneum* class	7	0·8	146	6·92	0·29
2. Erect plants with single or bunched shoots.	17	1·3	86	9·08	0·68
3. Bushy plants, broader than tall.	79	1·5	85	8·78	0·65
4. More or less depressed ...	57	1·5	91	8·45	0·68

2

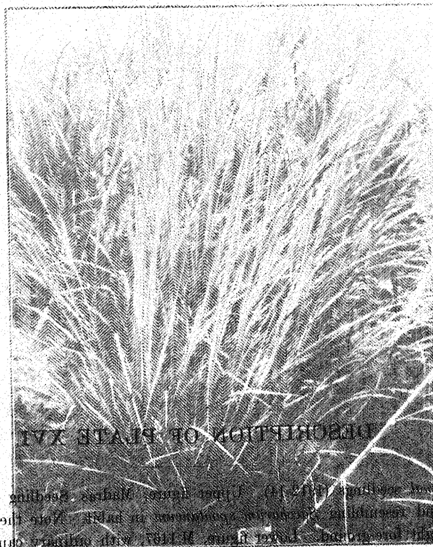


5

Habit types of Saretha selfed seedlings (1912-14). Fig. 1. Prostrate, with long branches

Habit types of Saretha selfed seedlings (1912-14). Fig. 3. Nargori-like. Fig. 4. Saretha-like.

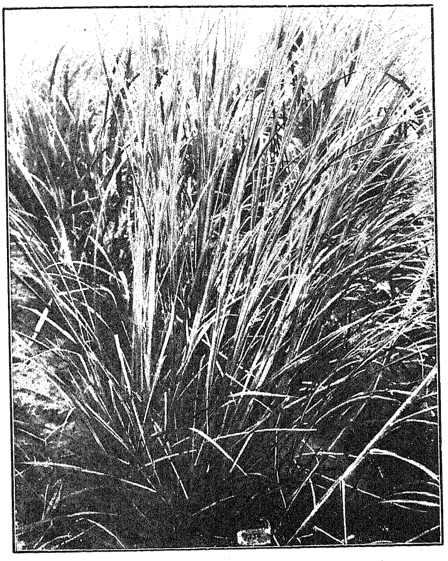
PLATE XVI.

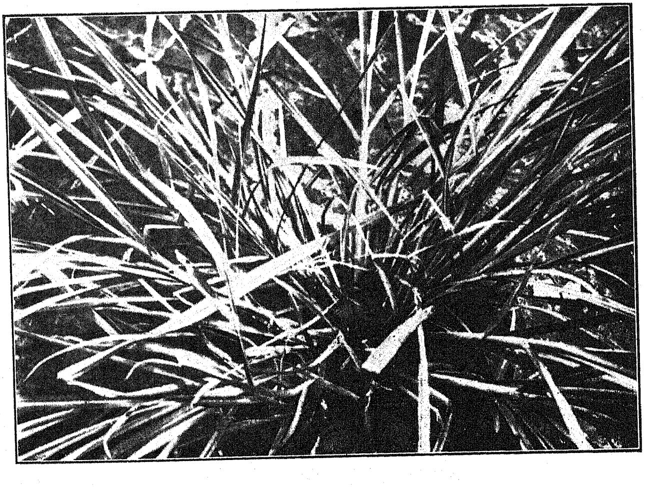


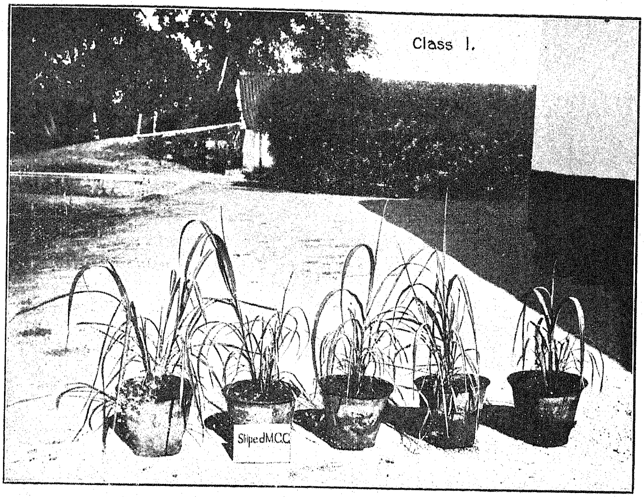
DESCRIPTION OF PLATE XVI.

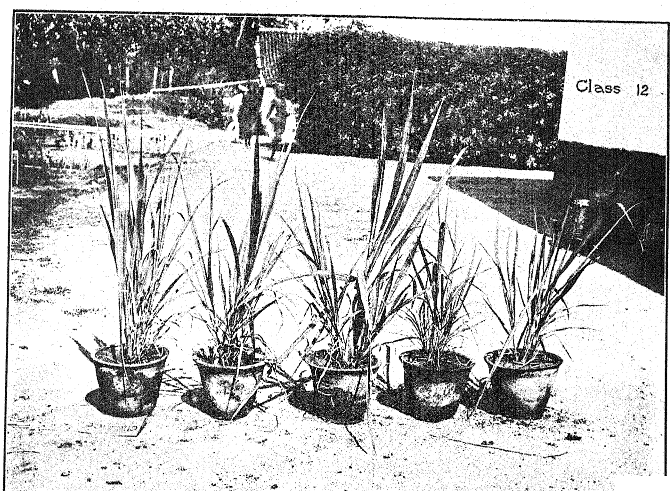
Naanal seedlings (1912-14). Upper figure, Madras Seedling 1354, narrow leafed and resembling *Saccharum spontaneum* in habit. Note the ground shoot in the right fore-ground. Lower figure, M.1467, with ordinary cane leaves, but depressed habit (see also Plate XXIV).

PLATE XVI.









An example of habit classes in young seedlings of Striped Mauritius (1914-15).
For description see the text, page 135.

It is seen that the early separation was quite successful as far as the *Saccharum spontaneum* class was concerned, but failed in the other classes, which give more or less uniform results at maturity.

In the examination of the seedlings during the (1914-16) season, considerable difficulty was met with in the attempt to combine several characters and obtain general habit classes while the seedlings were young. It is moreover to be noted that variations in habit are far less marked in the seedlings of thick canes than in North Indian canes. The following may be given as examples of such success as has been obtained. In the *Striped Mauritius* seedlings, 500 in number, some 30 (class 1) were picked out as smallish plants, dark green with some purple in the leaves, with a number of small purple shoots round a central one or two, the latter very erect, with a single, long, vertical, sharp-pointed youngest leaf, the next and succeeding leaves doubling back and heavily drooping, the leaves sometimes revolute or crumpled as if with excessive nutrition. Contrast with these class 12, with tall, wide leaves of a light green colour, the leaf ends strict and unbending until a much later period (Plate XVII). Whether such classes are influenced by unequal nutrition cannot be decided. It is obvious that with equal but limited root space and food material, a smaller plant would be in better circumstances than a bigger one ; and this may possibly account for the difference in leaf colouring, but it cannot account for difference in the size of the plants nor in their leaf endings.

One seedling among the 500 *Striped Mauritius* and one among the 350 seedlings of *B. 208* were depressed, narrow-leafed and more or less grass-like, being totally different from the rest in these and other respects. These, among other cases noted during the examination of the 1914-16 seedlings, remind one of the 7 curious plants in the (200) *Naanal* seedlings of 1912-14, which have been referred to already as resembling *Saccharum spontaneum*, the wild *kans* grass. The idea was formed from various facts that these *Naanal* seedlings are not in reality selfed but may be the result of a cross with that species (*cf.* section on Correlations, p. 172), but another explanation is here put forward, at any rate for the seven aberrant forms. It seems possible that we have here cases of " rogues " similar to those described by Bateson and Pellew in culinary peas (*Journal of Heredity*, V. 1). Five of these *Naanal* seedlings were selfed and crossed with *Saccharum spontaneum* in the 1913-15 season. The selfing was expected to result in a splitting by which their original parentage would be indicated. But all the seedlings were of the same type, narrow leafed, reminding of *Saccharum spontaneum*, but obviously not that grass. One of the 500 *Karun* seedlings of 1912-14 (Madras Seedling 1017) at once drew

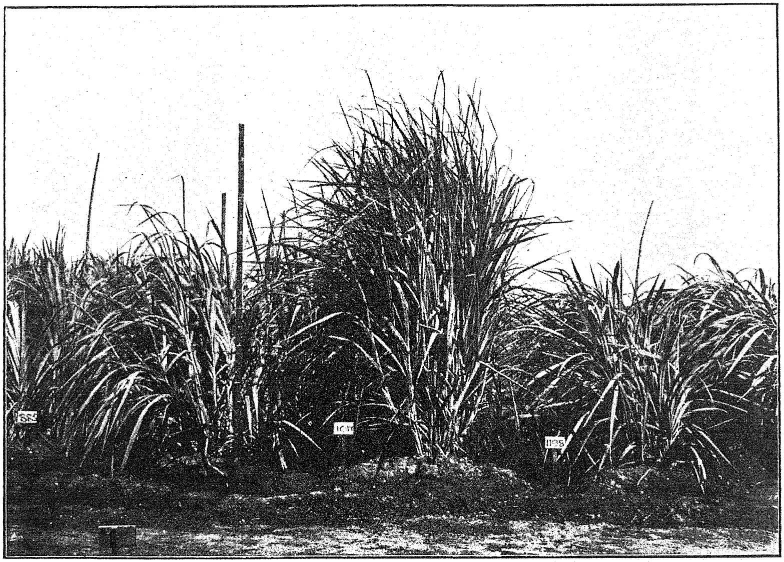
attention, when planted out in the field, by its great vigour. It had narrow leaves and was very tall and it had a very large number of canes, in fact, it stood out like a tree in its plot, being entirely different to the rest of the seedlings (Plate XVIII). It had little resemblance to *Saccharum spontaneum* and there is no reason for supposing that it is a cross. In fact, it shares with the aberrant *Naanal* seedlings a great flowering capacity, and has with them abundant open anthers and good pollen. This is a character not usually exhibited by crosses between sugarcanes and wild forms of Saccharum. The seedlings of *Shakarchynia* × *Saccharum spontaneum* (1912-14), *Chin* × *Saccharum spontaneum* (1912-14), and *Vellai* × *Saccharum Narenga* (1913-15), while extraordinarily vigorous and flowering profusely, were almost entirely infertile, as regards their male organs, the anthers being persistently closed and with unformed pollen.

Erectness of Young Shoots.

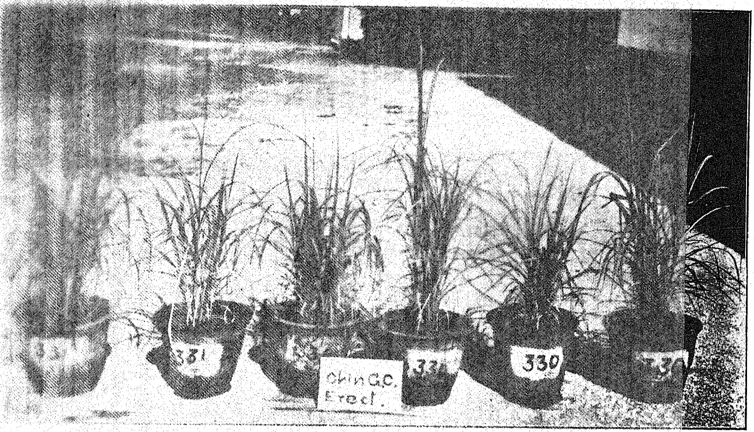
This is judged by measuring the angle made by the young shoots with the vertical line. As will be seen later, this angle varies with the age of the plant. All stages are met with in the seedlings between strictly vertical shoots and those depressed so as to be parallel with the ground, and there seems to be a connection between this obliquity in the seedlings and in their parents when planted from sets in the ground (Plate XIX). There is, furthermore, a great general difference between the thick canes and their offspring and the indigenous Indian canes and their seedlings in this respect, comparatively slight obliqueness being met with in the former. Such depressed habit in early growth is not unknown elsewhere. Besides many grasses, it is common in "wild paddies" and in certain wheats. It is also to be found in other classes of plants. For instance, the young plants of *Acacia leucophloea*, a perfectly erect tree, are often found lying prone on the ground.

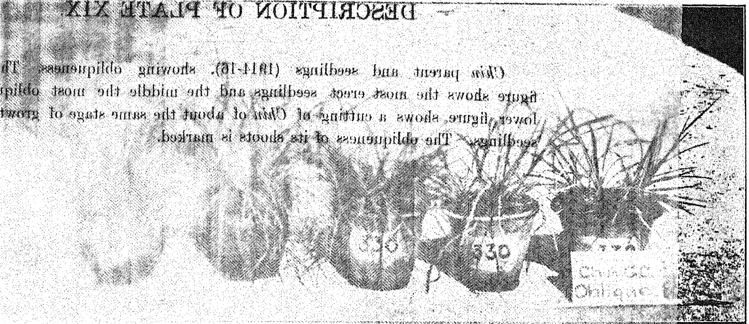
In *Striped Mauritius*, *Ashy Mauritius*, *B. 208* and *Java*, the parent shoots appear rarely to deviate from the vertical more than 20 degrees, and, in their seedlings, of which some 1,500 have been raised during the present season, the only two marked cases of depressed habit have been mentioned above, as solitary plants among the *Striped Mauritius* and *B 208* seedlings. *Karun*, *Chittan* and *Kaludai Boothan* seem to be similar in this character, but there were comparatively few seedlings raised in these varieties during the year. There would seem to be more obliqueness in the young shoots of *Vellai* than is usual in thick canes, but comparatively few seedlings were obtained from this cane during the year. A seedling raised in 1911-13, Madras No. 2 (*Kaludai*

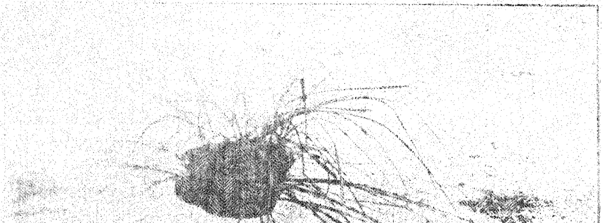
PLATE XVIII.



Madras Seedling No. 1017, a Karun (1912-14) seedling differing markedly from its neighbours. This difference was maintained when replanted from cuttings and the figure shows its growth in 1915-16. It is in "shot blade," as is its neighbour on the left.

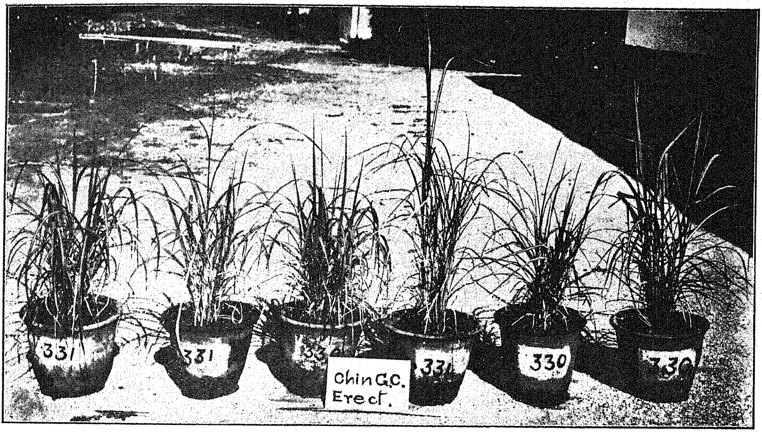

331
Chin G.C.
Erect.
331
330

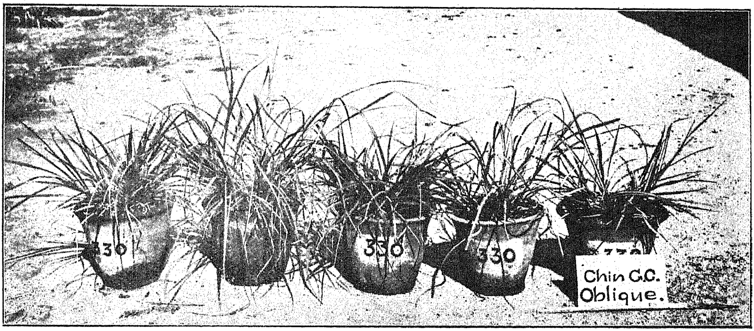

330
330
Chin G.C.
Oblique

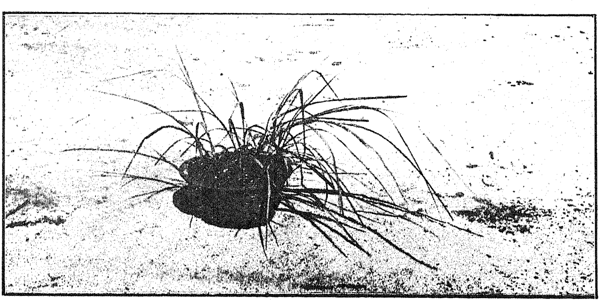


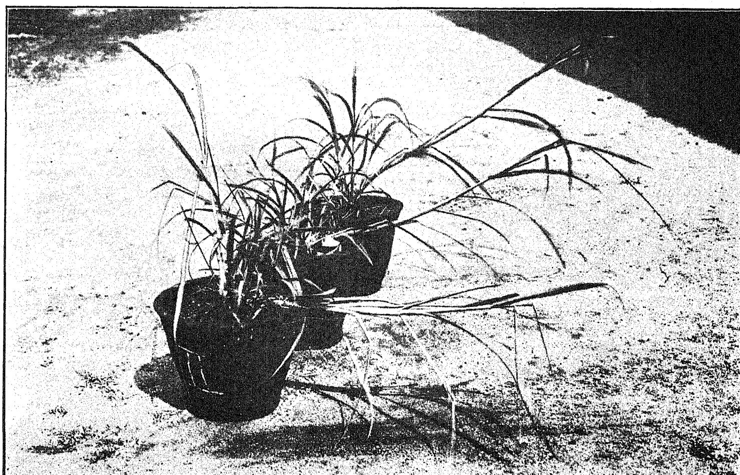
DESCRIPTION OF PLATE XIX.

Chin parent and seedlings (1914-16), showing obliqueness. The upper figure shows the most erect seedlings and the middle the most oblique. The lower figure shows a cutting of *Chin* of about the same stage of growth as the seedlings. The obliqueness of its shoots is marked.


331
331
331
Chin G.C.
Erect.
330
330

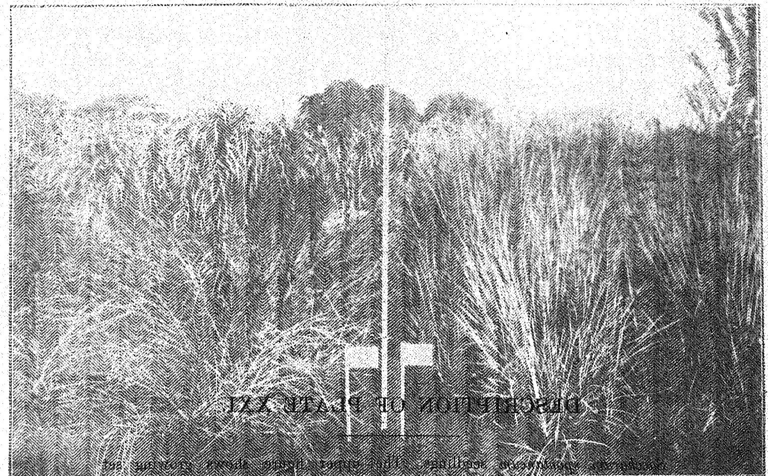

330
330
330
Chin G.C.
Oblique.

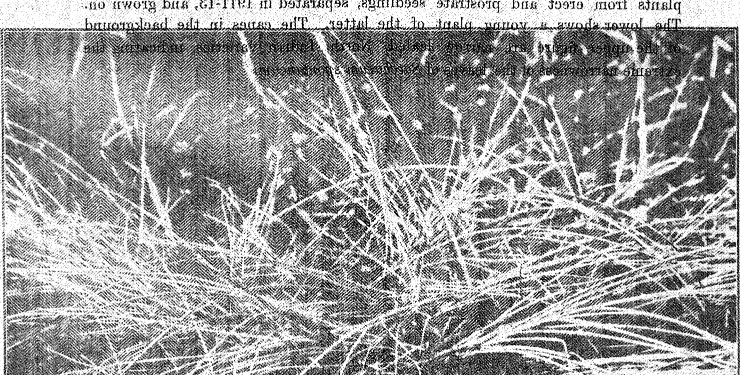




Saretha seedlings (1914-16), $5\frac{1}{2}$ months old and about to be planted out. A few of the rare, erect seedlings are figured, as well as some with the central, oldest shoot curving outwards and downwards, the later shoots being much more erect.

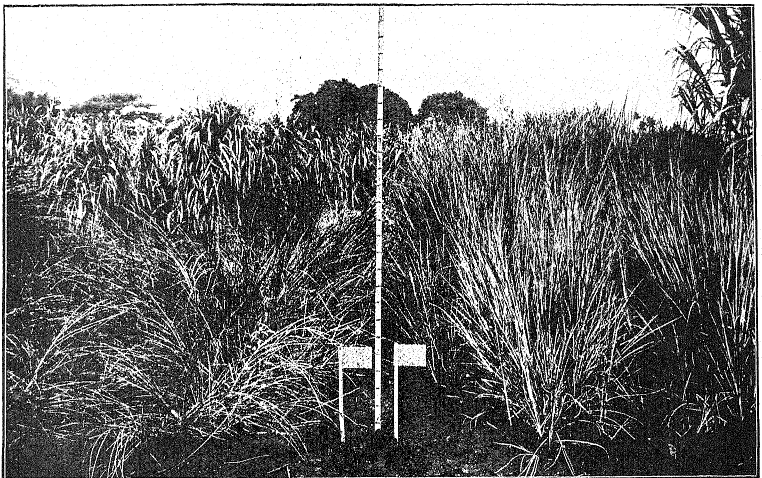
PLATE XXI

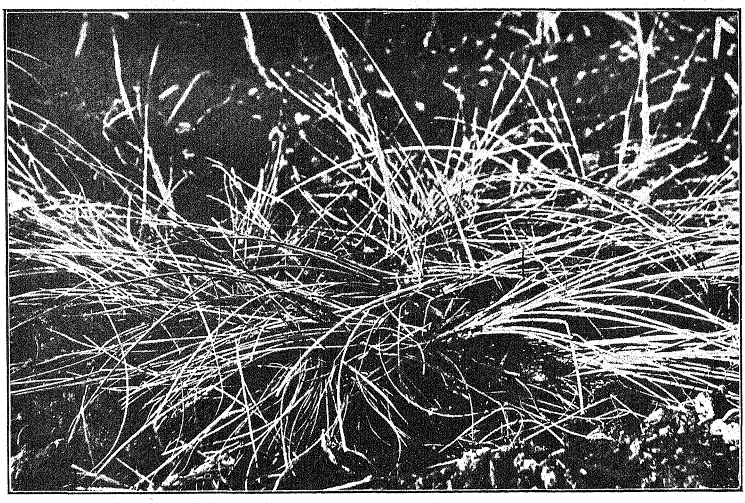




DESCRIPTION OF PLATE XXI.

Saccharum spontaneum seedlings. The upper figure shows growing set plants from erect and prostrate seedlings, separated in 1911-13, and grown on. The lower shows a young plant of the latter. The canes in the background of the upper figure are narrow leafed, North Indian varieties indicating the extreme narrowness of the leaves of *Saccharum spontaneum*.





Boothan parent) was, however, markedly oblique. There is some doubt as to the parentage of the seedlings collected at Coimbatore during that year, and this seedling differs a good deal from the *Kaludai Boothan* seedlings of 1912-14. It has now been carefully studied for some years and certain facts noted. In the first place, in it and the cases cited below, obliqueness tends to increase when the seedling is propagated by sets in the second year (*cf.* Plate XXIII). Secondly, of 100 selfed seedlings of Madras No. 2, only four show any trace of erectness, the rest being practically prostrate. Thirdly, when these seedlings were examined before planting out, there was little trace of the prostrate habit, owing doubtless to their being planted in pots and placed close together in the irrigating trenches. This is one of the directions in which the new system of saving labour in irrigating potted seedlings has worked badly, namely, in hiding the true character of the seedling (*cf.* p. 149).

Among Indian canes, *Naanal* is generally characterized by erect young shoots. But, among the seedlings raised in 1912-14, a great number showed a more or less depressed habit, possibly another reason for assuming that these seedlings were not pure *Naanal*. In *Pansahi*, although the mature plants are strikingly erect, there is a good deal of obliqueness in the young shoots, and this is reproduced in the seedlings, many of which show oblique or even prostrate shoots (*cf.* Plate I). *Chynia*, another member of the same class of North Indian canes, has young shoots which are practically erect and, although the seedlings are less oblique than in *Pansahi*, there are some which show depression. *Saretha* has very oblique young shoots and the seedlings are rarely erect, most of the 1,200 examined in 1914-16 being more or less oblique and many actually prostrate, and the same applies to *Chin* and its seedlings planted out in the same year (*cf.* Plate XIX). A special form of oblique shoots has been met with in these two varieties which is most striking. The first, oldest shoot, arising with slight obliquity, subsequently curves outwards and downwards and becomes very depressed, while subsequent shoots may be more or less erect. This peculiar habit is shown in *Saretha* seedlings in Plate XX ($5\frac{1}{2}$ months old) and is there contrasted with some of the rare erect seedlings.

It is interesting to note that the growth of *Saccharum spontaneum* resembles that of *Chin* and *Saretha* in many respects, including obliqueness and the characteristic outer, ascending shoots. Some of its seedlings have very oblique young shoots and one of them grown on from cuttings has become practically flat on the ground (Plate XXI). Crosses between *Saccharum spontaneum* and *Chin* and *Shakarchynia* (the latter a strict, erect cane from

Bihar) show this obliqueness very markedly. There is, in fact, general evidence that if there is any obliqueness in the parents, it comes out strongly in the seedlings and more so still when the latter are reproduced from cuttings.

The thirty-eight 1911-13 seedlings have now been grown for several years successively from cuttings, and notes and photographs have been taken at various stages in their growth. *Cheni* is marked by considerable obliqueness in its young shoots, and this has come out in the seedlings, all of which show this character in varying degree. By comparing the photographs taken it has been noted that, while the oblique character is distinctly traceable in all the seedlings at four months from sowing the seed, it increases until the seventh month, and then diminishes until, in the tenth, there is little trace of it left, the shoots gradually becoming erect as cane is formed. On making a similar comparison in the case of young shoots of these seedlings planted from cuttings, the obliqueness seems to be greatest at four months and, by six months, it has more or less disappeared. A series of photographs taken of growing sets of Madras No. 2 shows this change in habit very well, the angle of growth having been traced, in several cases, from germination until flowering. The mature cane is seen to be sinuous in shape, commencing at an oblique angle, this followed by further depression and finally erecting itself as the flowering period is approached. A paper on this subject was read by M. R. Ry. T. S. Venkataraman and myself at the Madras Science Congress in January 1915, and some of the lantern illustrations are here reproduced (Plate XXII).

It is natural to connect this early obliqueness of the shoots with a more or less straggling mature habit of the canes, and there appears to be some reason for doing this, in that *Chin* and *Saretha*, when growing luxuriantly in the field, are liable to fall and have to be propped. But it has been difficult to trace this connection in many cases and, on the cane-breeding station, the heavy winds and unusual rains during the past season have caused almost all the canes to fall and they have had to be raised and tied to bamboos, thus hiding their natural habit. Some canes showing early obliqueness quickly recover erectness, as for instance Madras No. 2 Seedling (Plate XXIII), but others, and especially some *Saretha* seedlings, remain prostrate for a great part of their existence. The time at which oblique shoots raise themselves and become ascending is at present undetermined in a large number of cases of seedlings, although it is fairly early in most cultivated canes. The seedlings of any batch, especially of North Indian canes, vary greatly in early erectness and, in consideration of its important agricultural bearing, marked attention has been paid to this character in classifying the seedlings in 1914-16.

DESCRIPTION OF PLATE XXII.

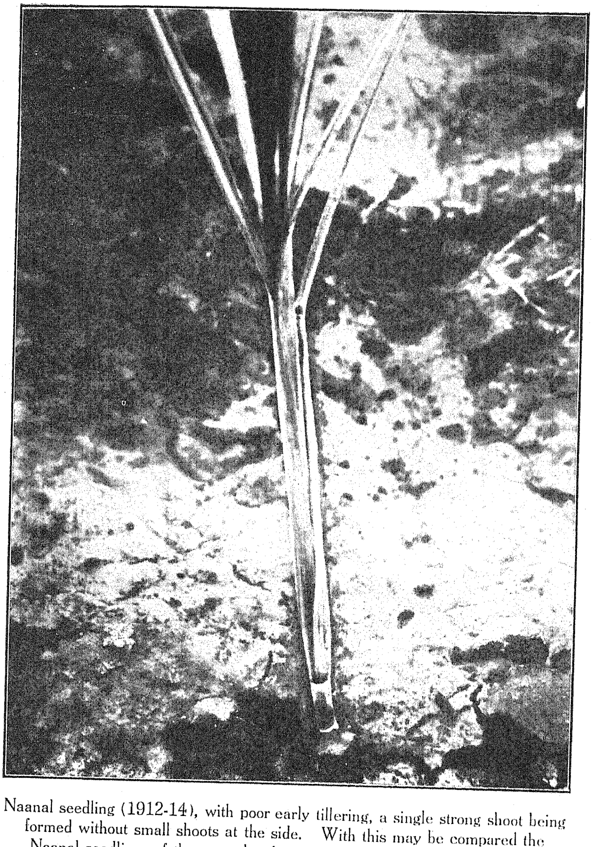
The figures illustrate the growth of cuttings of Madras Seedling No. 2 (*Kaludai Boothan* parent, 1911-13), from germination until the flower stalks are formed. Figs. 1-6 are of germinated sets, placed opposite holes in the sides of vertically placed pots. Of the 9 sets shown in Fig. 1, four were chosen in Fig. 2, to show how the degree of obliqueness increases with size. Three of these are shown at further stages in Figs. 3-5, and one of them is photographed in Fig. 6 just before flowering. Figs. 7-12 show a similar series, with one germinated set planted upright in a pot. The obliqueness is already very marked in Fig. 8, 18 days after planting, and in Fig. 9 it is shown that the downward tendency is hampered by the edge of the pot. The plant was raised and replanted on a heap of earth and stones in a bigger pot, and Fig. 10 shows further depression. In Fig. 11, erection has commenced and, in Fig. 12, the flowering stage is reached. (I am indebted to Mr. T. S. Venkataraman for taking these photographs which were prepared for a paper read by us at the Madras Science Congress of January, 1915).


1
2-7-14
11. A.M.
2
27-7-14
3
28-8-14.
4
5-10-14.
5
28-10-14.
6
16-11-14.
7
A
6-6-14.
2-30.
8
A
24-6-14.
8-40.
9
A
2-7-14.
9-10.
10
A
28-8-14.
11
A
30-10-14.
12
A
16-11-14.

DESCRIPTION OF PLATE XXIII.

The obliqueness of shoots in Madras Seedling No. 2. Fig. 1. Seedling $4\frac{1}{2}$ months old. Fig. 2. The same, 7 months old. Fig. 3. Germinated cuttings (second year), 3 months old. Fig. 4. The same, 6 months old.

PLATE XXII



Naanal seedling (1912-14), with poor early tillering, a single strong shoot being formed without small shoots at the side. With this may be compared the Naanal seedlings of the same batch and about the same age in Pl. XVI.

In conclusion, the depressed habit referred to above is not an uncommon occurrence. Many of the Gramminceæ show two markedly different growth stages, the first consisting of much branching of low shoots and the second of the erection of flowering spikes. But this habit of growth is not altogether disadvantageous, for it does not diminish the number of ears of grain borne aloft at harvest time. In the sugarcane the inflorescences are also erect, but that is of little importance, and the twisted nature of the stem is a matter of real concern.

Tillering.

Tillering varies a great deal among seedling canes, and the cause of this is not understood. Many of them, especially among the thicker canes, at first develop a single cane-like shoot which becomes quite large before any others are formed. Others again send out a number of smaller equal shoots which continue to grow for some time before one of them becomes a leading shoot and outstrips the rest (Pl. XXIV. See also Pl. XVI). The two extremes are usually only met with in the Indian canes, where we get, on the one hand, a single cane-like shoot and, on the other, a dense mass of small leafy ones with thin leaves, for all the world like a tuft of grass (*cf.* Pl. XIX). The latter form is not generally found in the seedlings of thick canes where, however, it is not infrequent for a seedling to develop a number of tallish, graceful branches so as to resemble a full grown plant of *tenai* (*Setaria italica*). No connection has at present been established between the number of shoots early developed and the mature habit of the seedling but, as a rule, seedlings of Indian canes have, like their parents, far more branches than the thick tropical ones. This is readily seen in the accompanying table.

Tillering in seedlings of various parentage.

	Parentage	Number of seedlings	Average number of canes	Average number of small shoots	Remarks
Thick Canes ..	Chittan ...	489	13	6	
	Karun ...	308	13·5	4·5	
	Kaludai Boothan	57	15	6	
	Poovan ...	13	11	6	
Indian Canes ...	Naanal ..	180	A great number, but not counted.		The number was especially large in "Spontaneum class" (*cf.* Pl. XVI)
	Saretha ...	49	Together 52		
	Cheni ...	18	44	13·5	
Cross with Wild Cane.	Shakarchynia × *Sacch. spont.*	62	81	Not noted	(*cf.* Pl. VI.)

Leaf Tips.

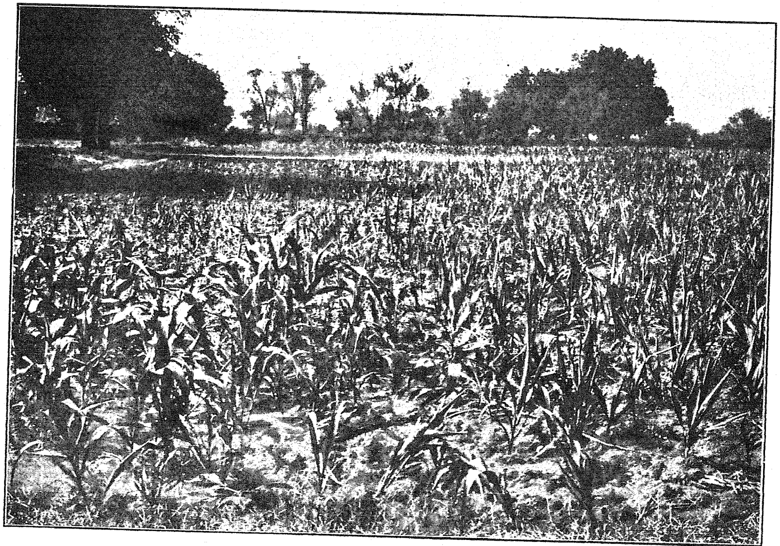
One of the most striking habit differences in cultivated canes is the form assumed by the ends of their leaves. Some, like *Shakarchynia* (Pl. VI, fig. 3), have stiff, unbending tips; others have a sharp bend or break near the end, as in most, if not all, of the *Chin* alliance (*Chin, Saretha, Katha, Kansar, Lalri*)[1]; others again, although moderately stiff, soon bend slightly as in the *Mungo* group; while the *Pansahi* group, consisting of *Pansahi, Yuba, Maneria, Lata, Dickchan, Sanachi, Kahu*[2] etc., have broad leaves which, from the first, soon bend in wide and graceful curves. There are similar differences in almost every batch of seedlings which has been examined. It is true that in many plants this curving of the leaf ends depends a good deal on the rate of growth and the amount of food and moisture available. Differences can be seen in any field of young *cholam* or *juar* (*Andropogon Sorghum*) (Pl. XXV), and on the banks of the railways among the various specimens of the stronger wild grasses, but, considering the fact that it is attempted to grow all the seedlings under identical conditions and that the varieties of cultivated canes differ so markedly in this respect at maturity, a good deal of attention has justifiably been given to the leaf tips in examining the seedlings. The bending does not seem to have anything to do with the width or the length of the leaf, nor with the general conditions of the plants and, accordingly, one of the first selections has been to pick out all the plants with strict, erect leaves whose tips do not soon bend. It was generally possible, in the 1914-16 seedlings, to obtain about 10% in each batch with erect tips, but *Cheni* and *Java* showed a stronger tendency towards this character. Most of the seedlings had leaves soon broadly curving, while here and there it was possible to pick out such as were distinguished by the leaves being bent back so that the upper part was almost parallel with the lower (*cf.* Pl. XVII).

Width of Leaf.

There is great variation in the width of the leaf in any batch of seedlings of common parentage (Pl. XXVI), while the general average width in different batches often hints at their parentage. In fifty young *Cheni* seedlings (1914-16) this variation was from 0·45″ to 0·90″, the broadest leaf being chosen in each case, and in *Kaludai Boothan* the difference was between 0·6″ and 1·3″. At

[1] Barber, C. A. *Mem. Dept. Agr. Ind. Bot. Series*, Vol. VII, No. 1, Pls. III and IV.
[2] *Ibid*, Pl. XVI.

PLATE XXV.



Young *Cholam* plants (*Andropogon Sorghum*), grown on the Cane-breeding Station. They were all sown at the same time, but those on the left are in a damper place. The difference in leaf tips is marked.

In conclusion, the depressed habit referred to above is not an uncommon occurrence. Many of the Gramminеæ show two markedly different growth stages, the first consisting of much branching of low shoots and the second of the erection of flowering spikes. But this habit of growth is not altogether disadvantageous, for it does not diminish the number of ears of grain borne aloft at harvest time. In the sugarcane the inflorescences are also erect, but that is of little importance, and the twisted nature of the stem is a matter of real concern.

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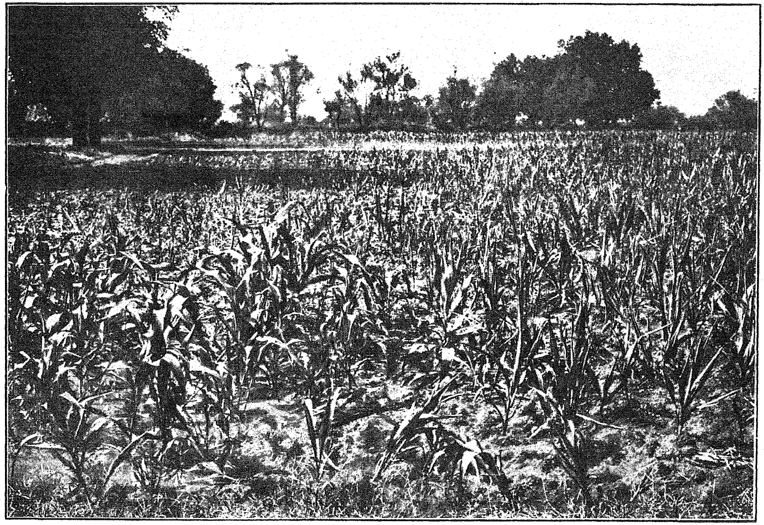
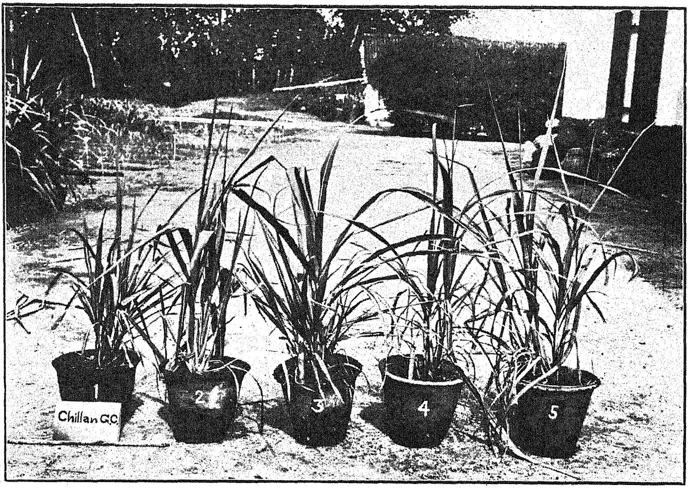
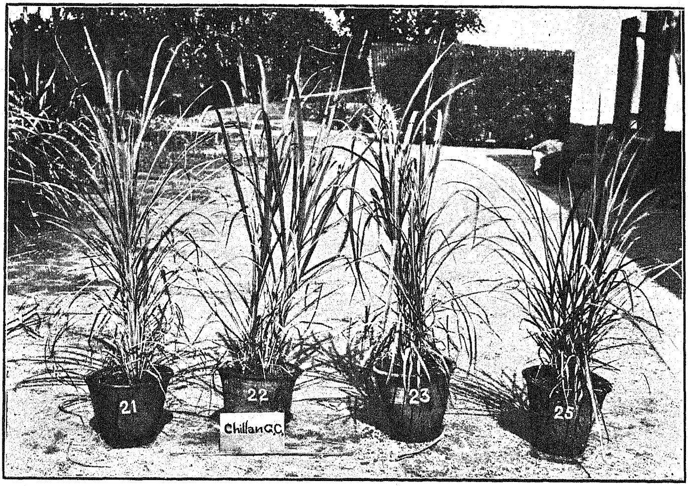


Young *Cholam* plants (*Andropogon Sorghum*), grown on the Cane-breeding Station. They were all sown at the same time, but those on the left are in a damper place. The difference in leaf tips is marked.





Chittan seedlings (1914-16). Typical broad and narrow leafed classes.

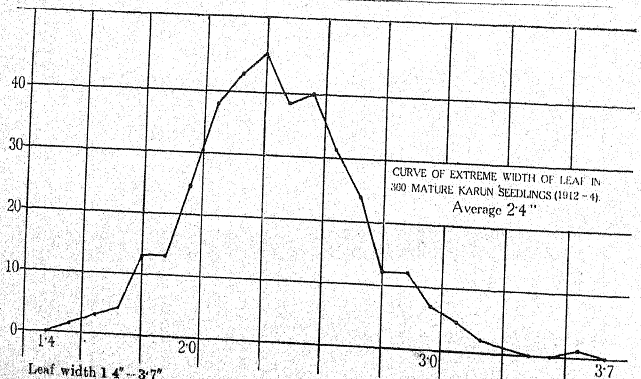
the first glance it is natural to assume that, in this leaf width, carrying with it greater assimilative power, there may be a difference in the ultimate value of the seedling and the quality of its juice. And this suggestion receives support in that the indigenous Indian canes are, as a whole, characterized by extremely narrow leaves as contrasted with canes grown in the tropics. Thus, the width of a leaf in the *Chin* group might be anything from 0·6″—1·3″, in the *Pansahi* group from 1·5″—2·0″ and in exotic canes from 2·0″—4·0″.

Considerable attention has accordingly been paid to leaf width in the seedlings examined. It must be conceded that there is a great deal of variation in the width of the leaves of each individual seedling, dependent on the vigour of growth and the age and position of the leaf on the stem. In order to obtain a common basis, it was decided to measure the widest leaves observable. All the seedlings are thus measured at crop time, ten shoots being taken and the widest in each measured and an average struck. This has given on the whole satisfactory results, and ordinary variation curves have been obtained for each set of seedlings. That for 360 *Karun* seedlings is appended below. But it has been found that this method is unsafe if applied to young and growing plants. In a batch of half grown *Karun* seedlings (1912-14), 236 in number, this method of averaging the widest leaf was adopted, but the classes resulting, when compared with those obtained in the same seedlings at crop time, showed many serious discrepancies, and this has led to a study of the leaf width of sugarcane plants at different periods of growth. In a growing shoot it was observed that, for a considerable period, each new leaf was on the average wider than its predecessor and thus, in seeking the widest leaf, this was usually found near the apex of the shoot. It is obvious therefore that the leaf width of any seedling, judged by this method, will be influenced by its relative vigour of growth as compared with its neighbours. The more rapidly growing seedling will obtain a higher place in leaf width than is justified by its ultimate development. It has not yet been ascertained at what stage the maximum leaf width is reached, but experimental measurements are being made with a set of plants to determine this. It has been assumed that, in fully matured plants with healthy leafy shoots, this error is eliminated, although it is possible that, by this time, a converse diminution of leaf width may have set in.

The accompanying table gives the leaf widths of the 1912-14 seedlings with approximate figures for their parents.

Average extreme leaf width of mature seedlings and parents.

Parents	Number of seedlings	Seedlings: Extreme cases	Seedlings: Av. of all the seedlings	Parents: 1	Parents: 2	Notes
Chittan ...	529	1·4—3·6	2·4	2·4	2·5	Each figure was obtained by taking 10 shoots, measuring the widest leaf and taking an average of the ten.
Karun ...	360	1·4—3·7	2·4	2·4	2·3	The average of all the seedlings in Chittan, for instance, is the grand average of the averages above mentioned in all the 529 seedlings.
Kaludai Boothan	75	1·3—3·3	2·4	2·5	2·8	The "Extreme Cases" are the lowest and highest averages obtained in these 529 seedlings.
Poovan ...	13	1·7—3·0	2·2	1·8	2·0	Two sets of observations were made for the parents, but in neither case were these well grown. The figures for the parents are thus only approximations.
Cheni ...	19	0·9—2·4	1·6	2·4	2·0	Graphs were prepared of all the sets of seedlings, of which one (Karun) is reproduced below. The others were similar
Naanal ...	73	0·6—2·1	1·4	1·9	1·65	
Saretha ..	45	0·4—1·9	1·0	1·1	1·3	
Shakarchynia × *Saccharum spontaneum*	64	0·3—1·3	0·8	0·9 / 0·4	1·25 / 0·4	



With actively growing seedlings another method has been adopted which it is hoped will lead to more satisfactory agreement with the comparative leaf width at crop time. This consists in viewing well-grown plants of the same age at a short distance, estimating the average leaf width and measuring a leaf which seems to represent this average. The following are variations recently obtained in this manner, *Ashy Mauritius* (150) 0·7″—1·9″, *Striped Mauritius* (500) 0·8″—1·7″, *Chynia* (60) 0·8″—1·75″, *Pansahi* (250) 0·7″—1·2″, *Chin* (200) 0·25″—0·90″. This method of judging the average is not very applicable to mature seedlings, because of their height and general inaccessibility.

Colour of the Leaves.

There is considerable difference in the leaf colour of different varieties and species of Saccharum. *Saccharum spontaneum* has bluish green leaves, *Saccharum arundinaceum* light grass green and *Saccharum Narenga* has more of a brownish tinge in the green, as grown at Coimbatore. *Katha* has glaucous green leaves and is thus readily distinguished from *Dhaulu of Gurdaspur* in which the bluish colour is less apparent, while members of the *Nargori* group may be frequently distinguished by a peculiar coppery brown tinge. In thick canes there are similar variations in tint which appear to be of taxonomic value. Among the seedlings examined, a glaucous tint is often met with in those of *Chin* parentage, and occurs in most of the seedlings which have *Saccharum spontaneum* blood in them. Some of the seedlings of *Java*, *Striped Mauritius*, *B 208* and *Saretha* have a marked purple tinge in the leaves, and in the two former varieties this colour invades the midrib, which becomes, in the absence of green there, a strong violet. Besides this, there are colorations due to the invasion of specific fungi, which seem to occur in certain seedlings and not in others. Striping of the leaves has not as yet been met with in the seedlings of indigenous canes, but it appears occasionally in seedlings of thicker canes. In *B 208*, *Striped Mauritius*, *Java* and some others, striped leaves occur regularly in about 2% of their seedlings. This is probably connected with incipient striping of the stems, a very rare occurrence in seedling canes (*cf.* under colour of canes, p. 146).

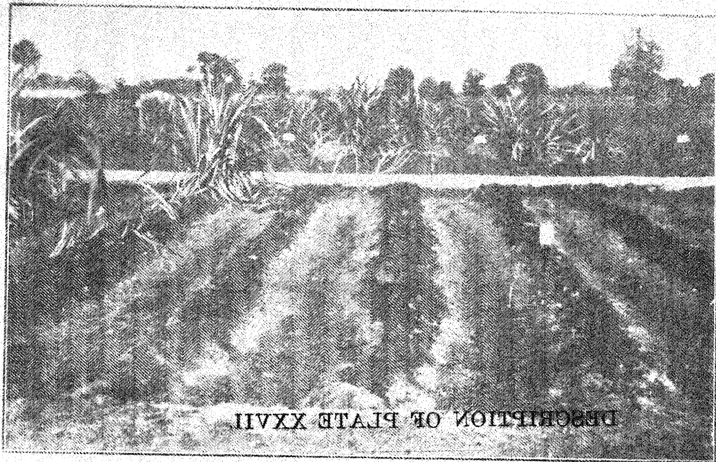
A marked difference can sometimes be noted between seedlings with dark green leaves and those of lighter, yellowish green, but this difference may be either inherent or due to alkalinity or salinity of the soil or irrigation water, and this fact makes it necessary to exercise some care in classifying the seedlings according to this character. There is hardly anything in which cane varieties differ more than in their capacity for resisting excess of salts in the soil and, as there is a good deal of salinity in the Cane-breeding Station, this

has been carefully studied (*cf.* Pl. VII and the text). The first indication of the effect of salinity is seen in the yellowing of the leaves. An interesting fact was noted in a batch of *Saretha* seedlings transplanted direct from the pans into the ground, when three months old. A preliminary separation was made, at six months, between dark green seedlings and such as had light green or yellowish green leaves, but the final examination was delayed for a week, after which some of the dark green seedlings were noted to have become yellow. There was heavy rain during the week. The cause of this was at once understood, and may be explained by the curious effect produced by heavy rain shortly before the Agricultural Conference met at Coimbatore in 1913. The field of cane varieties was healthy and dark green, when a couple of inches of rain fell, and the whole field turned yellowish. After some study, the following explanation was offered and this has been substantiated by further observations. The slightly saline land, during irrigation in the trenches had accumulated a layer of brown, powdery earth just above the point to which the water reached, each ridge showing this layer distinctly at the point where, presumably, evaporation was strongest (Pl. XXVII). On analysis, this powdery earth showed the presence of as much as 11% of salts, chiefly sodium chloride, and the heavy downpour appears to have washed the salt down to the roots of the canes with resulting yellowing. Any attempt at classification according to the light and dark green colour of the leaves of seedlings must be approached with caution.

Coloration of the leaf sheath, other than that due to disease, is a well marked distinguishing character in young seedlings, although it becomes difficult later on. The sheaths may be pure green, although this is comparatively rare. They are usually tinged with light purple, pink or a vinous colour. Sometimes they are strongly violet or bluish purple or even a clear pink, and a number of classes have been instituted according to variations in the colour of the leaf sheaths, which is rarely constant in any batch of seedlings. The colour of the very small shoots, although depending primarily on the colour of the leaf sheaths, appears to be of a somewhat different character. They are either green, purplish green, dark purple or sometimes almost black.

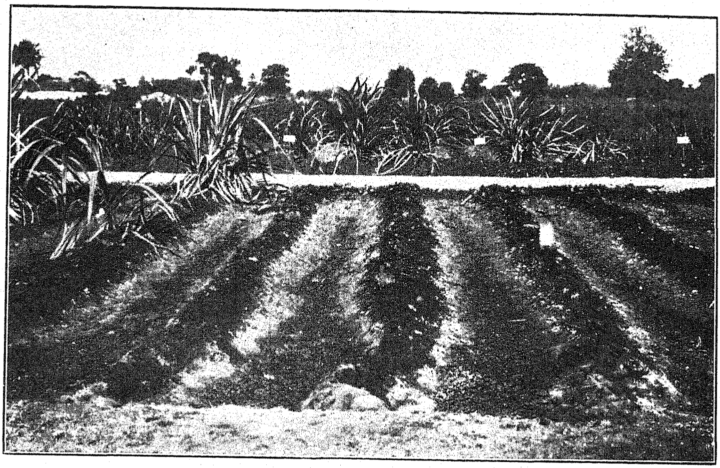
The colour of the transverse marks (the small triangular patches of colour on each side at the base of the lamina where it joins the sheath) is easily seen in young seedlings, and affords a useful separation character. The colour varies from very dark chocolate to purple, reddish and brown to wax coloured, yellow, green and greyish white, the latter probably owing to bloom.

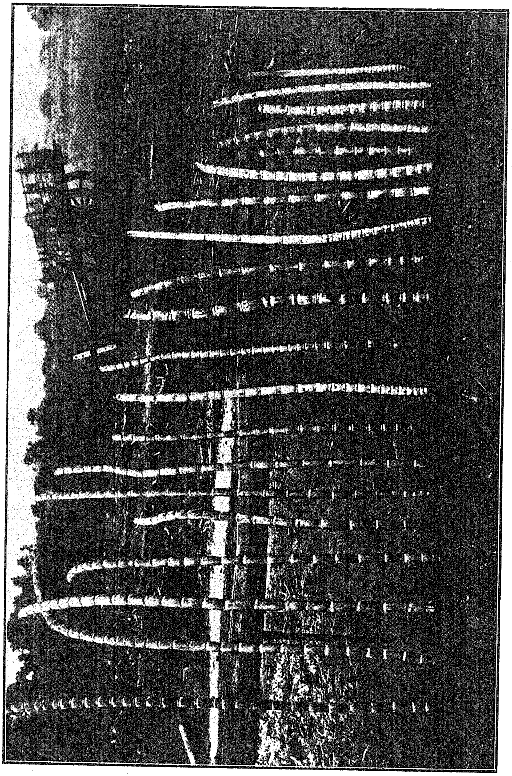
PLATE XXVII



DESCRIPTION OF PLATE XXVII.

Formation of a layer of brown, powdery, saline earth in irrigated trenches in the Cane-breeding Station. This was on untreated land where the canes were first planted, in 1913. For details of this powdery earth, which is formed at the point of greatest evaporation, consult the text. The poor growth of the thick canes is seen at the side. The central portion was unplanted.





Average canes taken from 20 Karun seedlings (1912-14), harvested on one day (May 6). These were in no way selected, but merely such as were analysed in rotation on the same day. The canes show marked differences in length and thickness, size and shape of joints and, obviously, in colour, although the latter is only indirectly indicated by differences in shading.

Colour of the Canes.

In no respect do the seedlings of any one batch differ more widely among themselves than in the colour of the canes (*cf.* Pl. XXVIII). It is moreover extremely difficult to classify these colours, because of the number of different shades in any one cane, and it is probable that each observer would adopt a different system of grouping. It is, naturally, not possible to determine the colour of a cane in very young seedlings and the following facts have been elicited from a study of the seedlings of 1912-14 at crop time, the colour of all having been recorded when they were prepared for final chemical analysis. The classes adopted were as follows:—

(1) Green, including various shades of green, yellow, grey to almost white through heavy bloom, there being no tinge of brown, pink, red-brown or purple present.

(2) Brownish and vinous tinged greens.

(3) Purple, claret and red, the latter being rather indefinite, but neither claret nor purple.

(4) Striped.

Subjoined is a table giving the colours of the parents and the proportional colours of their offspring.

Colour of canes in seedlings and parents.

Parents	Colour of parent	Number of Seedlings	Green	Brownish	Vinous	Brown or Red	Purple	Claret	Striped	Remarks
			%	%	%	%	%	%	%	
Chittan ...	Striped, claret and green or yellow.	468	56	14	8	3	14	4	0·04	Striping of parent breaks down.
Karun ...	Claret ..	337	44	9	8	14	5	17	0·1	Comparatively large percentage of clarets.
Kaludai Boothan	Greyish green with vinous tinge.	56	43	10	43	2	...	2	...	Comparatively large percentage of vinous.
Saretha ...	Green when young becoming brown or red when old.	50	46	...	8	46	.	...	...	Comparatively large percentage of browns and reds.
Naanal ...	Green ..	84	46	33	20	...		...	..	Greens with brownish and vinous tinge.
Cheni ...	Green ..	25	80	12	8	...	...		...	Too few seedlings available.
Poovan ...	Greyish green.	14	29	13	29	7	21	..	.	

There are one or two interesting and unexpected features brought out in this table. In the first place, the colour of the parent has some little influence, although comparatively little, on the colours to be found in the seedlings derived from it. This influence is seen in the comparatively larger proportion of clarets in the *Karun* seedlings, vinous in *Kaludai Boothan* and *Poovan*, browns or reds in *Saretha* and greens in *Cheni*. But it is a rather curious fact that the proportion of the greens is fairly uniform in most of the groups. With the exception of the last two classes in the table, in which few seedlings were available, this proportion is more or less 50% of the total number of seedlings in each case. Of the total 1,034 seedlings in the list, 49% are greens.

The question of *Striping*, again, is always of interest. One would expect that, in the seedlings of *Chittan*, a striped cane, there would be a larger proportion of cases with striping in the stem. But this does not appear to be the case. The striping breaks down completely in the seedlings, and, when it occurs, it is connected with striping of some of the younger leaves. It appears that this coloration arises as a sport in one-colour canes. The following instances of this have been noted in recent years in Madras, and there are doubtless others which have escaped the rather perfunctory attention given to the subject. *Red Mauritius* (a dull or dark claret cane) has been observed to sport in two directions. A variety of common appearance has full and dark red stripes, and another less common one has an element of green alternating with the red. A set of *Maneria* (a greyish green cane) plants received from Sabour has shown several striped sports. *B. 376* shows occasional striped sports, and a striped sport is recorded of *B. 1529*. Most of these have been subsequently lost, from one cause or another, and in a good many cases the striping was not very pronounced. Once, however, a striped cane has arisen, it frequently splits into its two component colours. Thus, in every field of *Striped Mauritius* and *Striped Tanna*, green sports are found, in the latter case the green or yellow easily blushing bright red in the sun, as this colour does in the parent stem. *Striped Singapore* (possibly a local variation of *Chittan*) has been observed also to produce greens. Red sports are less common, but a well authenticated case has been met with in *Striped Mauritius*, the cane thus arising being of considerable agricultural value.[1]

Thickness of Canes.

This was measured at crop time in the 1912-14 seedlings. As seen in the accompanying table, the thicker canes produced the thicker seedlings, and the

[1] Note In recent examinations of indigenous Indian canes, a faint striping of one or two joints has been not infrequently noted, April 1915.

range of variations in any batch of the same parentage is more or less constant, the thinnest cane being, roughly, half the diameter of the thickest. The thickness was determined by spreading out 20 canes, selecting the average and measuring it at the middle. The accompanying photograph (Pl. XXVIII) gives some idea of the variation in seedlings of the same parentage in this and other respects.

Thickness of canes in seedlings and parents.

Parents	Thickness in parents	Number of seedlings	Extremes in thickness of seedlings	Average thickness in seedlings	NOTES
	cm.		cm.	cm.	
Chittan	2·7	473	1·5 – 4·4	3·2	The thickness in any seedling was judged by spreading out 20 canes, selecting an average one and measuring it at the middle in a plane at right angles to that passing through the bud.
Karun	2·9	318	2·0 – 4·9	3·3	
Kaludai Boothan ..	3·2	56	2·4 – 4·4	3·2	
Poovan	3·1	11	2·2 – 4·0	3·1	
Naanal	2·1	65	1·3 – 2·8	2·1	The thickness of the cane in the parents is an average of previous measurements found in the notes on these varieties grown in various places. Measurement was done by calipers and is in centimetres.
Cheni	2·2	18	0·6 – 1·2	2·0	
Saretha	1·5 – 2·0	43	1·1 – 2·3	1·8	
Shakarchynia	1·5 – 2·0	62	0·8 – 1·6	1·1	
× *Sacch. spontan.* ..	0·5 – 1·0				

The above mentioned are the chief characters in which young seedlings have been found to vary. Other minor differences, such as length of internode (usually greater in Indian canes), flatness of leaves (whether incurved, revolute or crumpled), colourings due to minor leaf fungi or insect or other attacks, and so forth, have been noted, but the results are at present too vague to be used in classification. The whole of the 3,400 seedlings planted out in 1914-16 have been divided up into groups according to these characters, and the following classes in 500 *Striped Mauritius* seedlings (general collection) may serve as a type of the method adopted. The seedlings were examined in two lots, of 300 and 200, which accounts for duplication of classes.

Class 1.—(40 seedlings) Some purple in the leaf.

Class 2.—(50) Plants with bright pink leaf sheaths.

Class 3.—(9) Some striping in the leaves.

Class 4.—(30, practically all that were discoverable) Sheaths green, with hardly a trace of purple or pink,

Class 5.—(40) Leaves revolute or, at any rate, sinuous.

Class 6.—(20) Leaf tips with a sharp backward curve, the youngest leaf usually with a long erect point, otherwise resembling the last class.

Class 7.—(20) *Tenai*-like seedlings (*Setaria italica*).

Class 8.—(20) Broad leafed plants, with strongly growing shoots, the broadest leaves of which varied between 1·6″ to 2·0″ in width.

Class 9.—(20) Narrow leafed plants, with strongly growing shoots, the broadest leaves of which were less than 1·3″ wide.

Class 10.—(20) Transverse marks sharply coloured.

Class 11.—(20) Transverse marks not strongly coloured, often pale green or yellowish.

Class 12.—(10) Leaf tips erect (only 12 being met with).

Class 13.—(40, all that could be found in 200) Duplicate broad leafed lot, widest leaves varying between 1·3″—1·6″.

Class 14.—(40, although more could have been obtained in 200) Duplicate narrow leafed lot, widest leaves under 1·3″.

Class 15.—(10 plants, all that could be obtained in 200) An addition to class 6, small, slender, dark green seedlings with poor tillering.

Class 16.—(30) More or less bushy plants, with or without a main strong shoot.

Class 17.—(30) Not bushy, with strong main shoot and few others.

The remaining 32 unclassified, with 8 selfed seedlings added.

A certain amount of correlation between some of these characters is noticeable (see also General Habit classes, p. 133 *et seq.*). Thus the "*Tenai*-like" plants, resembling *Setaria italica*, with a number of equal but not very strong shoots, are usually of a light green colour, and their leaves are narrow and bend gracefully at the same angle all round. The typical purple-leafed plant has dark green foliage, the plants are usually small but look very healthy, the young shoots are very dark in colour and the leaves bend back very sharply, often with one very long, acicular point in the middle of the plant. The pink-sheathed plants are often large, with comparatively few shoots and without dark coloured small shoots. The erect-tipped leaves usually belong to plants of a pale green colour, often broad leafed, and so forth. These correlations have not been definitely settled, but they give the impression that further study will show that certain infantile characters of the seedlings will be found to be related and, if this can be proved, a great step in advance will have been made, for all present indications point to the fact that any classification of the cultivated sugarcanes must be based on the accumulation of a number of,

often very minute, morphological characters which, taken together, give the plant an indefinable but real form of habit.

One of the chief difficulties met with, in this habit study, has been (as already stated) that the method of arranging the seedlings in their early stages has been dictated by the need for economy in watering. They are at first raised in shallow pans and then pricked out as soon as they show themselves likely to be healthy and vigorous. They are transferred to nine-inch pots when 6″ to a foot high, and these are arranged in wide trenches so that they can be watered all together by filling the trench (*cf.* p. 114). They are usually kept in the pots until about six months old and then some of them are already four or five feet high. The disadvantages attending this procedure was very clearly shown in the *Saretha* seedlings raised during the 1914-16 period. Owing to the very large number of healthy seedlings available, a set of one thousand were planted in rough ground, at one foot apart, when three months old. Another large lot were planted in pots in the usual manner and irrigated all together. Yet a further lot were retained for five months in their pans and then potted. Some hundreds were left in their pans and not even pricked out, while, lastly, a batch was planted in the ground when quite young, close together, being intended for the supply of failures in those raised in the pots. These separate lots of seedlings were examined and photographed at six months of age and varied, from six feet high, in those planted early in the ground close together, to 1—2 feet where left in the pans. The habit in all but one lot was fairly uniform and no classification was well possible according to this. Only those planted one foot apart in the ground showed habit differences well, and these varied from absolutely prostrate, through strongly oblique, by various stages, to nearly erect, besides showing other differences, such as in the shape and denseness of the plants.

VARIATION IN THE SUCROSE PERCENTAGE IN THE JUICE.

The chemical analysis of the juice of the seedlings and cane varieties is a heavy tax on the staff at disposal. Because of the incidence of most of this work at one time of the year, it was not thought necessary to attach more than one chemical assistant permanently to the staff of the Sugarcane Expert, but it will easily be gathered, from what follows, that this assistant is quite unable to deal unaided with the work during the period of stress. I am indebted to the Government Agricultural Chemist for generously placing two of his assistants at my disposal during the whole of the cropping season, thus making three altogether available for the chemical analysis of the canes.

The data obtained in the analysis of a seedling are as follows :—number of canes cut, weight of canes crushed in lbs., weight of juice obtained, percentage of juice to cane, Brix (corrected) per cent., sucrose per cent. in the juice, glucose per cent., glucose ratio and co-efficient of purity. For various reasons, in judging the value of a seedling, it has not been considered sufficient merely to make an analysis of the juice at harvest time. For one thing, the season is so long protracted, because of the number of analyses to be got through, that some of the seedlings would be heavily handicapped by this method, and, for another, time is available before harvesting commences to make a series of preliminary analyses to gauge the rate of ripening in the plots, so as to be able better to judge the date at which the final analyses should be made. The former series of analyses, made on one or two canes, is termed the "petty series" and the final analyses the "bulk," dealing as it does with what canes remain in each clump. There is little doubt that the seedlings of different parentage differ very considerably in their order of ripening, and the petty analyses give some idea as to the order in which the plots should be cut for final analysis.

The total number of analyses made since the foundation of the cane-breeding station (excluding preliminary soil analyses done by the Government Agricultural Chemist) are as follows :—

1912	Cane Juice	12	Others	52	(miscellaneous)
1913	,,	92	,,	43	(mainly well water)
1914	,,	2909	,,	33	(mainly chlorine determinations in cane juice)
1915	,,	400	,,	38	

In order to form an estimate of the relative richness of the juice in the seedlings, the plan usually followed in other countries was at first employed, namely, to consider the bulk analysis at crop time. But certain peculiarities in some of the curves obtained led to a full study of the whole series of bulk and petty analyses, and it was seen that to take the bulk alone into consideration might be misleading. For instance, during the 1914 harvesting season, in order to test the ripening of the canes, certain of the *Naanal* seedlings were analysed once a fortnight, and the results are given in the table appended.

Fortnightly analyses of the juice in Naanal Seedlings (1912-14).

Madras No. 1411	Sucr.%	6·63	6·65	7·32	6·09	7·71	6·87	5·30	6·79	7·06	6·06	...
	Gluc.%	2·94	2·38	2·08	1·60	1·79	1·67	1·47	1·28	1·30	1·47	...
Madras No. 1439	Sucr.%	10·26	9·13	10·83	10·39	9·89	10·32	10·53	7·52	9·31	10·04	10·63
	Gluc.%	2·08	2·08	1·67	1·92	1·67	1·25	1·14	1·11	1·16	1·25	0·67
Madras No. 1454	Sucr.%	4·79	6·22	7·30	7·84	7·03	6·83	5·86	13·40	14·48	7·21	...
	Gluc.%	2·17	2·08	1·39	1·60	1·56	1·38	1·11	0·40	0·32	0·17	...
Madras No. 1474	Sucr.%	10·31	11·19	11·94	13·48	14·00	14·47	13·00	10·31	9·28	8·46	...
	Gluc.%	1·72	1·67	1·53	1·39	1·04	1·16	0·74	0·40	0·63	0·61	...
Madras No. 1490	Sucr.%	7·57	8·18	9·53	9·36	8·81	12·53	10·92	10·71	8·00	9·44	9·93
	Gluc.%	1·67	1·61	1·19	1·20	1·00	0·68	0·54	0·36	0·54	0·37	0·33

In all of these there is a steady fall in glucose percentage from start to finish. In Nos. 1411 and 1439, the sucrose varies little throughout the series, and a very fair idea would be obtained of the richness of the juice from the bulk analyses alone. In Nos. 1474 and 1490, on the other hand, there is a fairly steady rise in sucrose to a maximum, followed by a decline towards crop time, showing apparently that the canes were overripe when finally analysed in bulk. It is thus seen that the glucose determination alone is not sufficient to determine ripeness in a cane, as it continues to fall when the cane is overripe. The figures in No. 1454 show extraordinary variations, and no reliable opinion can be formed from them as to the normal richness of the juice. On the whole, it will be observed that the bulk analyses is not always a safe guide, and, after an examination of other cases, where petty and bulk analyses were available, it was finally determined to select, from the series of analyses of any seedling, that containing the highest reading of sucrose. In doing this, however, due regard has been paid to the percentage of glucose and the botanical description made at crop time. Where the former was unusually high or a note was recorded in the latter that the canes were immature or dried up and overripe, the analysis was rejected. After all, the main purpose of these analyses is to obtain a comparative figure of a seedling's merit, and it is felt that this will be best obtained by some such method as that adopted. It may perhaps give a rather high figure for the general richness of juice in the seedlings grown on the farm, but it is, again, thought

that this will be counterbalanced by the fact, illustrated below, (p. 155) that seedlings elsewhere have given better juice than on the farm itself.

In comparing the values of the juice of different seedlings, and in studying the correlations mentioned in the next section, at first the Brix, sucrose, glucose and co-efficient of purity were copied out and averaged. It was soon seen, however, that the excessive labour involved would materially restrict the work, and also that, usually, it would be sufficient to consider only the sucrose and glucose. Finally, even this was simplified and only the sucrose was averaged, care being taken to see that the glucose warning of immature canes was not neglected.

Comparison of sucrose in the juice in parents and seedlings, 1912-14.

	Parents				Seedlings			
	Number of analyses	Locality	Range of sucrose %	Average sucrose %	Number of seedlings analysed	Locality	Range of sucrose %	Average sucrose %
Chittan ...	5	Cane breeding Station.	15—18	16·67	500	Cane breeding Station	8—21	14·7
Karun ...	3	do.	15—18	16 02	345	do. ..	10—20	14·7
Kaludai Boothan	4	do.	14—20	16·78	60	do. ...	10—17	13·8
Saretha ...	5	Aligarh Farm 1913	13—17	14·59	51	do.	1—18	14·6
	15	Cane breeding Station	11—17	13·83				
	4	Wet lands, Coimbatore Central Farm.	18 - 19	18·91				
Cheni ...	12	Cane-breeding Station	11—14	12·67	19	Botanic Garden, Coimbatore, 1913.	9—15	12·2
	5	Wet lands, Coimbatore Central Farm.	18	17·67				
	10	Mysore ..	16—19	17·01	16	Cane-breeding Station, 1914.	13—17	15·2
Poovan ...	5	Cane breeding Station	13—17	14·61	17	do.	12—20	15·0
Naanal ...	12	do.	9—16	12·36	180	do.	5—17	10·5
	3	Wet lands, Coimbatore Central Farm.	15—17	16·37				
Chin × ...	9	Cane breeding Station	12—16	13·81	18	do.	6—12	9·0
	7	Wet lands, Coimbatore Central Farm.	15—18	17·30				
	7	North India ...	14—15	14·78				
Saccharum spontaneum		Cane breeding Station	3—5	4 00				
Shakarchynia ×	5	Cane-breeding Station	9—16	12 94	81	do.	6—13	9·8
	4	Sabour Farm (Taylor, 1911)	17	16 94				
Saccharum spontaneum		Cane-breeding Station	3—5	4·0				

In the accompanying table, details are given of the amount of sucrose in the juice of the seedlings of 1912-14 and of one lot of *Cheni* in 1911-13. It will be seen that there are considerable variations in the sucrose content of

seedlings of the same parentage. Thus, the *Chittan* seedlings varied from 8% to 21% and *Naanal* from 5% to 17%, and, generally speaking, the more analyses recorded in any one lot, the wider the range of the sucrose in the juice. There is also a definite relation between parents and offspring in this respect, the better parents producing the better seedlings. The analyses of the crosses are also interesting, in that they show that the sucrose in the seedlings approximates to the average of the two parents. In the other cases, of seedlings from parents not specially crossed, or " general collections," the average sucrose of the seedlings is generally lower than that of the parents, and this may be due to the fact, stated elsewhere, that it was not always possible to analyse a seedling at its optimum. Note must also be taken of the character of the land on the farm, for many varieties have given very poor results there. Thus, in *Cheni*, a Mysore cane, while ten analyses at Bangalore gave an average sucrose percentage of 17·01, twelve on the farm gave only 12·67, a figure more comparable with that in the seedlings. So also, *Shakarchynia* in Bihar gave 16·94, whereas on the farm it only reached 12·94. There is also a very marked difference in the results obtained on the Cane-breeding Station and on the heavy tank irrigated land on the adjoining Coimbatore Central Farm. The local canes, *Chittan*, *Karun*, *Kaludai Boothan* and *Poovan* also gave analyses a good deal lower in the seedlings than in the parents, but not sufficiently so as to suggest crosses with a wild Saccharum, of which, moreover, there was no trace in the morphological characters of the seedlings. In *Saretha* and *Chin*, there appears to be less difference between the juice anaylses collected from North India and those made at Coimbatore, suggesting that, for these canes at any rate, the conditions on the farm are fairly comparable with those in North India.

The prime object of the Cane-breeding Station is to raise new and hardy canes for North India, which will be capable of being grown in the fields under ryots' treatment and, in order to judge how seedlings raised at Coimbatore would behave in various parts of North India, some nine of the earlier seedlings of various parentage were distributed to Pusa, Shahjehanpur and Jubbulpore. It is unfortunate that analyses have only been recorded at the latter place, but seedlings have also been grown on the Central Farm wet lands and on different soils in the station itself. The accompanying table gives the sucrose and glucose in the juice of a set of seedlings grown outside the farm. From this table it will be seen that the seedlings respond readily to changes in soil and water, and there appears to be some probability that, in general, seedlings raised in the farm will, if anything, improve in the quality of their juice when grown elsewhere.

Comparison of the Juice of Seedlings grown under different conditions (all bulk analyses).

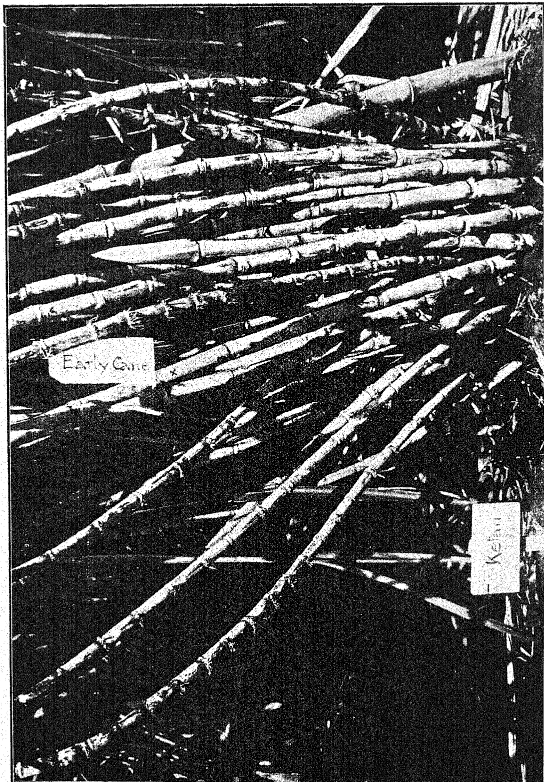
Seedling and its parentage	GARDEN LAND AT COIMBATORE (well irrigated): Botanic garden 1913[1]		Cane-breeding station A 1914		Cane-breeding station B 1914		Cane-breeding station B 1915		Wet land in Central farm Coimbatore (tank irrigated) 1915		Adhartal farm Jabbulpore 1914-15	
	Sucrose %	Glucose %	Sucrose %	Glucose %	Sucrose %	Glucose %	Sucrose %	Glucose %	Sucrose %	Glucose %	Sucrose %	Glucose %
Madras No. 2. (Kaludai Boothan)	11·55	1·53	10·24	0·71	13·18	0·52	12·21	1·11	14·58	0·67	15·21	1·24
Madras No. 6. (Poovan) ...	11·88	1·45	7·95	1·32	9·60	0·94	9·34	1·43	13·83	0·48	13·04	1·60
Madras No. 11. (Poovan) ...	12·40	0·92		Failed.	13·64	0·65	16·09	1·10	17·26	1·00	...	...
Madras No. 19. (Cheni) ...	11·43	0·22	12·89	0·86	12·64	0·65	13·26	0·48	16·75	0·10	12·74	1·12
Madras No. 21. (Cheni) ...	12·36	0·16		Failed.	12·50	0·17	15·07	0·52	18·20	0·30	14·49	1·02
Madras No. 25. (Cheni) ..	14·68	0·10	11·86	0·51	12·56	0·56	13·96	0·81	15·72	0·33	14·63	0·90
Madras No. 29 (Cheni)	15·33	0·10	9·79	0·38	13·64	0·30	15·55	0·17	17·32	0·10	...	...
Madras No. 45. (Cheni) ..	10·05	0·17	10·83	0·61	15·81	0·65	11·74*	0·67	17·78	0·29	14·71	1·02
AVERAGE .	12·31	0·58	10·59	0·73	12·95	0·55	13·40	0·79	16·43	0·41	13·13	1·15
Average of five grown at all places	11·94	0·69	10·75	0·80	12·76	0·66	12·10	0·90	15·73	0·37	14·07	1·18

NOTES

[1] First year seedlings grown in large pits filled with good soil but irrigated with brackish water.
In 100,000 parts of water:—Total solids 239, injurious salts 165, sodium chloride 127.
A. Set plants grown first year from seedlings—in small pits filled with good soil; earth around saline; and irrigated at any rate at first with brackish water.
In 100,000 parts of water:—Total solids 342, injurious salts 249, sodium chloride 189.
B. Set plants grown first and second years from seedlings—in smaller pits filled with good soil; earth around slightly saline: irrigated with sweet water.
In 100,000 parts of water:—Total solids 91, injurious salts 53, sodium chloride 33.
* 14·82 in petty analyses, therefore probably over-ripe.

This varying behaviour of Madras seedlings grown in different localities raises the interesting question as to whether there is anything like it in ordinary cultivated canes. A good deal of attention has been given to this question and a number of analyses of certain cane varieties have been collected from different places. It is hoped that, in time, sufficient data will be accumulated, (1) to be able to forecast the probable behaviour of selected canes and seedlings when moved from one locality to another, and (2) to get a general idea of the suitability of different localities for sugar production in India.

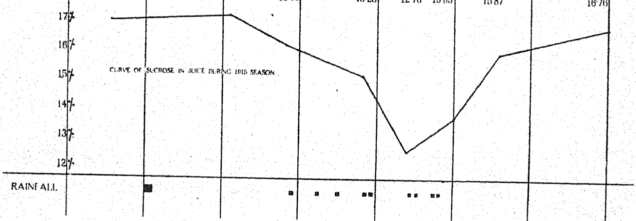
The question as to the permanence of the juice characters of cane seedlings, when propagated as sets, is one of considerable importance and has been studied as far as data are available. Many of the 1911-13 seedlings were found to yield far better juice when planted in the second year from sets. But the seedlings had been planted in very large pits with good soil and their growth was in some cases very vigorous, and it is regarded as possible that this may have had a prejudicial effect on their ripening. Besides this, the great variations noted above in the richness of the juice in seedlings, when planted under different conditions, renders it unsafe to form conclusions from isolated cases. There is also another matter, already referred to, which may have an effect on the juice of seedlings when first analysed, namely the period of year at which they are cropped. Owing to the restricted arrowing season, the seedlings mature from June onwards, whereas the proper time for ripening canes in this locality appears to be much earlier in the year. Lastly, the weather also appears to have considerable influence on the character of the juice. The seedlings during the present (1915) harvesting season show this markedly, and much trouble has been caused by unseasonable rains. During the ripening season, usually a time of some anxiety as to whether any rain will fall, we had this year as much as 10 inches, and this appears to be reflected in the juice analyses, the cropping time being in general three months later than in the previous year. The canes in the varietal plots appear to have been practically ripe at the beginning of April but, after that, stimulated to renewed growth by the unusual rains, the sucrose percentage fell steadily, and it was not until the dry period in July-August that there was a sensible recovery. In these conditions the richness of the juice shown by the replanted 1912-14 seedlings suffered, and in many cases was not so high as in the first cropping season. The variations in sucrose in the juice are shown in the accompanying table, all the analyses in which were made up to dead leaf (*cf* p. 163). The series of analyses are spaced according to the part of the month in which they were made. Below, is an average of the sucrose in the four varieties chosen, with a curve to represent it graphically, while at the base is a series



Clump of Ketrai (Pansahi-like form) one year old, showing the presence of "early" and "late" canes. One of the former has a label attached, while a late cane is marked by a cross.

of dots indicating the falls of rain. There is a remarkable descent in the curve until the middle of June, after which recovery is rapid. Similar variations in sucrose content were met with in many of the seedlings, as shown by their petty and bulk analyses.

	FEBRUARY.	MARCH.	APRIL.		MAY.	JUNE.		JULY	AUGUST.
DATE OF ANALYSIS	19th		2–5th	24th	25th	11th	29th	16th	31st
JAVA	19·20		19·44	16·99	17·02	13·43	15·43	17·21	17·00
J. 139	18·52		18·04	17·31	14·65	13·35	12·72	17·21	19·05
J. 213	15·50		16·45	15·89	15·10	12·25	14·82	14·28	15·54
CHENI	14·57		14·62	14·26	14·16	12·02	12·34	14·78	15·47
AVERAGE	16·95		17·14	16·11	15·23	12·76	13·83	15·87	16·76



It is, thus, of obvious importance to get the seedlings as soon as possible into line with the local time of sowing and reaping, and to avoid these irregularities as far as may be. At present, after reaping them in June to August, they are planted in beds and will ripen about a year later. But, in future, cuttings will if possible be taken from the young canes in February and these will be planted in the ordinary varietal plots, which have been hitherto, for one reason or another, planted late each year. According to this arrangement, the seedlings collected, say, in December 1915, will be first analysed in June 1917, the second analysis being in February 1919. These dates throw a side light on the length of time required for a seedling to be tested, the 1919 analysis being by no means the latest one necessary before forming an opinion as to its value. An additional advantage of this February planting will be that sets will be available for distribution to North India at the usual planting time there.

As in the case with cane varieties, extraordinary variations have been met with in a seedling, in analysing the different canes in the clump. This has led to increased care in sampling. For petty analyses, the canes chosen are

as far as possible without any rooting or shooting, and are such as would develope into healthy canes at crop time. Those which are abnormal in any way are rejected, and the same precaution is taken at crop time, the idea being to try and obtain such results as would be given by a mass of healthy, well-grown canes. But, besides this, attention has been paid during the past season to the fact, pointed out in the recently published Memoir on Punjab Canes,[1] that, in some varieties, there are usually two kinds of cane in each clump, differing not only in certain morphological characters, but also in the time of origin and therefore in age. In the paper referred to, there was no opportunity of testing the chemical character[2] of the juice of these two classes of canes (termed "early" and "late"), but this has been observed during the current (1915) cropping season. The results of this study, carried out at my request by Mr. T. S. Venkataraman on some of the varieties growing in the Cane-breeding Station, are detailed below. It will be seen that they agree closely with those obtained in the Punjab case, in that this peculiarity (of two classes of canes being present at crop time) is confined to certain varieties of canes and is not appreciably present in others, suggesting a profound difference in the mode of formation of the branches, a subject which is receiving further attention. As detailed in the paper referred to, the early canes are characterised by commencing with short, narrow joints which gradually increase in length and thickness upwards, whereas the late canes commence with long joints of full thickness which are succeeded by others which become shorter and thinner upwards. This has been our main criterion, and another character of the early and late canes has also come out strongly, in that the early canes have many joints while the late ones have few. Mr. Venkataraman has found that the cane varieties examined on the farm may be divided into the following two classes as regards the formation of early and late canes in each clump.

(1). Varieties in which early and late canes can be separated easily. It would appear that in these varieties there is a continual production of canes, which may be divided into early, intermediate, and late. To this class belong *Pansahi*, *Chynia*, *Yuba*, *Maneria*, *Sanachi*, *Kahu* and the *Pansahi*-like *Ketari*, all of them belonging to the *Pansahi* group of *Ganna* canes of North India. A photograph of *Ketari* is appended in which the differences between early and late canes can be clearly seen (Pl. XXIX). Taking the length of the lowest joints as the criterion, we find a close relation between this

[1] Barber, *Ibid* p. 38, *et seq.*
[2] *Ibid*, p. 41.

character and the average number of joints developed, as will be seen from the following table :

Average number of joints in early and late canes.

	Early Cane		Late Cane	
	Number of canes examined	Average number of joints	Number of canes examined	Average number of joints
Maneria	14	36	10	20
Yuba	12	33	12	19
Pansahi	2	31	2	24
Kahu	1	38	4	21

The next table gives the chemical analysis of the juice in early and late canes. The samples have been taken in two ways. Those termed "ryots' sample" refer to the whole cane with such part of the young shoots cut off as is done by the ryot when milling. "Dead leaf" means that only the lower part of the cane has been taken, namely, that portion which bears dead leaves, the cane being cut at the point where the highest dead leaf springs from the stem.

The character of the juice in early and late canes.

Variety	Date of planting	Date of analysis	Kind of sample	Class of cane	Number of canes tested	Sucrose %	Glucose %	Co-efficient of purity
Maneria (all from one clump).	2nd June 1914.	19th May 1915.	Ryots'	Early ..	5	11·30	0 77	74·69
			,,	Late ...	2	9·52	0·52	69·40
Maneria (from the whole row).	2nd June 1914.	21st May 1915.	,,	Early ...	9	10·27	0·91	73·6
			,,	Intermediate.	10	9·99	0·85	73·2
			,,	Late ...	8	7·24	1·35	60·2
Yuba (all from one clump).	2nd June 1914.	21st May 1915.	,,	Early ...	6	10·61	1·09	72·0
			,,	Late ..	6	7·84	1·19	62·4
			Dead Leaf.	Early ...	6	11·22	0 91	74·8
			,,	Late ..	6	9·83	0·78	70·6

The table shows us that it is necessary to exercise caution in taking samples of these varieties. If the classification of canes into early and late is neglected, great differences in sucrose are likely to be met with in taking successive canes from the same clump, and the known irregularities in this respect are likely to be intensified.

(2). Varieties in which the separation of early and late canes is difficult or impossible. These varieties appear to form their canes up to a certain period and then cease. *Baroukha* (Sabour), *Ekar* and *Kaghze* may be taken as types. In these, although it was not found easy to separate early and late canes in the clump, the attempt was made according to the length of the basal joints, with the following results, as regards the total number of joints in the canes.

Baroukha, number of joints in all the samples analysed on 31st May		32, 33, 32, 30.
Kaghze,	do	35, 36, 34, 34, 33, 33.
Ekar,	do	35, 37, 37, 36, 39, 37.

There is no separation here into few and many jointed canes in the clump. The analysis of the juice in these canes is given in the table

Attempted separation into early and late canes.

Variety	Date of planting	Date of analysis	Kind of sample	Class of cane	Number of canes tested	Sucrose % in the juice	Glucose % in the juice	Co-efficient of purity
Baroukha	5th June 1914	17th May 1915	Ryots'	Not classed ..	15	9·91	0·56	72·5
		31st May 1915	,,	Early ? ...	2	9·38	0·50	71·1
			,,	Late ? ...	2	9 27	0·45	71·4
			Dead Leaf.	Early ? ...	2	10·72	0·50	75·5
			,,	Late ? ...	2	10·62	0·33	75·9
Kaghze	1st June 1914	15th May 1915	Ryots'	Not classed	15	9·46	1 56	69·3
		31st May 1915	,,	Early ? ...	2	12·01	0·77	77·4
			,,	Intermediate ?	2	12·39	1·14	76·4
			,,	Late ? ...	2	11·66	1·00	75·2
			Dead Leaf.	Early ? ...	2	11·15	1·04	76·9
			,,	Intermediate ?	2	12·81	0·71	82·0
			,,	Late ? ...	2	12·86	0·68	79·8
Ekar ...	5th June 1914	17th May 1915	Ryots'	Not classed ...	14	12 80	0·59	78·7
		31st May 1915	,,	Early ? ...	2	12·79	0·33	78·6
			,,	Intermediate ?	2	12·46	0·46	78·9
			,,	Late ? ..	2	12·34	0·33	78·7
			Dead Leaf	Early ? ...	2	13·74	0·37	81·3
			,,	Intermediate ?	2	12 77	0·24	81·4
			,,	Late ? ...	2	13·68	0·31	81·5

There is no trace of the different classes as regards cane juice, met with in the *Pansahi* group. These varieties thus will present comparatively little difficulty in sampling, as far as regards class of cane, and it is probable that many of the thick canes resemble them in this character.

There is no doubt as to the great improvement in the character of the seedlings grown on the farm in each successive season. The accompanying table gives the general average of the sucrose content in each lot of canes raised in 1913-15, which may be compared with the table on p. 153 of the 1912-14 results. From a perusal of the list of canes used as parents (*cf.* section on Enumeration of Seedlings), it will be gathered that this improvement is mainly due to the higher class of the latter.

Average % of sucrose in the juice in the 1913-15 *seedlings.*

Variety	Number of seedlings analysed	Sucrose % in the juice		Remarks
		Range of variation. The middle figure indicates the maximum in the curve	Average	
Karun Gen. Coll. ...	59	7—13—19	13·3	
Do. Selfed	12	8—12—18	13 6	
Chittan Gen. Coll.	74	6—13—20	14·3	
Kaludai Boothan Gen. Coll. ...	204	7—16—21	15·3	
Vellai × *Sacch. Narenga* ...	95	6—12—17	11·5	
Do. × Ashy Mauritius ...	87	9—16—22	15·9	
Do. × Karun	22	11—17—20	16·6	
Do. × Striped Mauritius ...	42	11—17—20	16·2	
Do. × Fiji C	72	8—13—20	15·0	
Do. × Chittan (1)	..	......	...	(1) These batches consisted of very few seedlings analysed and have been omitted.
Do. × M. 1354	22	7—12—16	10·9	
Do. × M. 1464	13	9—11—16	11·2	
Do. × M. 1428	20	10—13—15	12·6	
Poovan Gen. Coll.	14	12—15—20	15·9	
Do. Selfed (1)	...	...	...	
Java (Hebbal) Gen. Coll.	138	13—19—21	17·7	
B. 208 Selfed	50	12—18—20	17·4	
Do. Gen. Coll.	59	11—18—23	17·6	
Striped Mauritius (Hebbal) Gen. Coll. Do. (Central Farm) Genl. Coll.	} 127	12—16—21	16·5	
Do. do. Selfed (1)	...	... ...	...	
White Mauritius Gen. Coll. ...	21	12—17—20	16·6	
Do Selfed (1) ...	...	... ..	...	
Red Mauritius (1)	...	......	...	
Green Sport of Striped Mauritius ...	59	13—17—22	16·9	
Red Sport of Striped Mauritius ...	14	11—17—19	16·6	
Fiji B (1)	...	..	...	
Fiji C Selfed	20	13—16—20	15·5	
Fiji C Gen. Coll. (1)	...	......	...	
Ashy Mauritius (Central Farm) Gen. Coll.	31	11—15—21	16·2	
Do. do. Selfed ..	38	12—17—20	16·5	

Taking the whole series of *selected* seedlings during the past three seasons we see that the sucrose in the seedlings has steadily risen, as follows :—

Sucrose in the juice of selected seedlings.

	Number of seedlings grown	Over 17%	Over 18%	Over 19%	Over 20%	Over 21%	Over 22%	Over 23%	REMARKS
1911—13 (Over 17%) ..	48	2	..	..	..	..	..	..	All the seedlings were grown on.
1912—14 (Over 17%) ...	2,068	95	40	9	2	...	...	..	The standard of selection, 17% sucrose in the juice and over.
1913—15 (Over 18%) ...	2,400	400	128	101	22	3	1	1	The standard of selection, 18% sucrose in the juice and over, together with vigorous growth.

But it is a question whether the extremely high sucrose content attained is altogether in accordance with the ultimate aim of the Cane-breeding Station. Although high sucrose is an undoubted gain, the question as to whether the canes giving this will succeed in North Indian conditions is altogether another matter, and can only be determined after long series of experiments. On the face of it, it does not appear likely that rich canes of exotic parentage will be the best for North India, and it will, therefore, be even an advantage if the general level of sucrose content be lowered, if this implies the greater infusion of North Indian parentage. During the 1914-16 season every effort was made to obtain seedlings of this character. But, of the multitude of crosses attempted, comparatively few have succeeded, owing to the sterility or ill-timed emergence of the North Indian arrows and, in their place, a large number of seedlings have been raised from *Saretha, Chin, Pansahi* and other Indian parents, pure and simple. This will mean the lowering of the general average of sucrose in the juice during the next season, but the results are, perhaps, more likely to be of ultimate value than when, as in the 1913-15 season, comparatively few North Indian canes appeared among the list of parents. As stated elsewhere, the aim which is steadily held in view is to secure crosses between the best North Indian canes, such as *Saretha, Pansahi, Mungo, Chin,* and richer, thicker, tropical canes, and the arrowing plots have been laid down with this object in view.

There is no doubt that, but for the timely assistance of the Government Agricultural Chemist, in lending the service of two of his assistants during crop time, progress would have been comparatively slow. But, even as it

is, the completion of the seedling analyses in the limited period of ripening is an extremely difficult matter, and many seedlings suffer from not being analysed at their optimum. An innovation has been introduced in the petty analyses during the 1915 cropping season, which promises to quicken up the work in future. On going through any batch of seedlings for the first time, it is considered sufficient, in the place of the full petty analysis, merely to take the Brix reading of the juice, and at once to pass on to other seedlings if this does not reach a certain figure. This, it is claimed, will give a fair indication both of the ripening and of the relative value of the seedlings. Further, relying on the theory of phytomers, whereby each segment of a plant with its leaf or leaves is considered to be a more or less independent part,[1] an attempt has been made with some success to get an early indication of the ultimate value of a seedling by analysing some of the lower, apparently mature joints. The limiting joint thus far chosen has been the highest in which the attached leaf has completely withered. It is a question as to what further changes take place in the juice contained in such a joint, but the joints of the canes are very clearly separated from one another by their internal structure, and it is difficult to see how the juice in them will undergo great changes after the supplying leaf has died. The results obtained are on the whole suggestive, and there seems to be some promise, on the adoption of the analysis of the cane up to the highest dead leaf, of obtaining early indications as to which seedlings are worth going on with. If the method proves to be fairly satisfactory, it will be possible to rule out in any batch a large number of inferior seedlings and thus save much time in the final analysis.

[1] This must not be taken too literally and is perhaps more of a morphological than a physiological conception. That neighbouring joints in a *growing* cane are without influence on one another is very unlikely, and this lack of independence has been strongly brought out by J. Kuijper in his paper "Is een blad met un internodium bij het riet als un physiologische eenheid op te vatten"? *Med. Præfst. v. d. Java-Suikerindustrie.* Deel V. No. 15, 1915.

CORRELATIONS BETWEEN MORPHOLOGICAL CHARACTER OF SEEDLINGS AND THE RICHNESS OF THEIR JUICE.

The correlations thus far studied at the Cane-breeding Station are based chiefly on the characters of sugarcane seedlings of the 1912-14 period, and must be regarded as an introduction rather than as a piece of completed work. The data were unsatisfactory in many minor points, and it is hoped that further work will follow as new series are subjected to the necessary tests. The 1912-14 seedlings were examined at crop time according to a prepared scheme and, although it was found necessary, during the examination, here and there to alter certain of the particulars, thus destroying continuity in some characters, sufficient data were accumulated for averages to be struck, especially in the larger batches of seedlings. The heavy descriptive work was under the charge of my Botanical Assistant, Mr. T. S. Venkataraman, to whose energetic persistence I am greatly indebted.

The correlations observed, although sometimes very distinct, do not exclude very considerable irregularity in each series. This is not to be wondered at when the conditions have been noted. The recorded results are at best approximations, as has been fully conceded in the sections on variations among the seedlings in morphological and other characters. The chemical analyses used, again, are the highest observed during petty and bulk tests ; they are probably, in many cases, not a very accurate gauge of the comparative richness of the juice and will, to a certain extent, be influenced by the number of analyses taken of any particular seedling. Even then it was found advisable ultimately to concentrate attention only on the sucrose contained in the juice, merely noting the glucose in order to rule out obviously unripe specimens. The detailed botanical descriptions were also largely consulted in order to eliminate those seedlings which were abnormal in their growth and either immature or overripe. The morphological characters were carefully observed, but the seedlings were of unequal growth at crop time, there were a very large number to be dealt with and the time of the staff available was strictly limited. Our knowledge of the parentage of the seedlings was also

incomplete, and it is possible that some of the irregularities noted may be due to the presence of crosses in the general collections.

The following is the list of seedlings examined :—

(1) 1911-13. A small lot of *Cheni* seedlings (about 18) which were very carefully studied, but were grown under somewhat abnormal conditions.

(2) 1912-14. About 500 *Chittan* seedlings, over 300 *Karun*, 50 *Kaludai Boothan* and 13 *Poovan*, all general collections in the field, that is without any knowledge of possible local crossings: 50 selfed *Saretha* seedlings and 65 crosses between *Shakarchynia* and *Saccharum spontaneum*.

(3) 1913-15. About 80 crosses between *Vellai* and *Saccharum Narenga*.

These seedlings were studied with regard to the following possible correlations. The leaf width at maturity was compared with the sucrose in the juice, with the thickness of the cane, the total weight of the seedling and the number of canes and shoots, as indicating tillering power. Other characters compared with sucrose were the length of leaf, the leaf module (length divided by width), thickness of cane, length of cane and cane module (length divided by thickness), and colour of cane. In a number of these comparisons a distinct correlation has been observable, but it is important to remember that this does not mean that a uniform series was obtained. The greatest variations occurred in all the series, and it was only on taking them as a whole and dividing them into classes, that the tendency was definitely established. While, for instance, the general tendency is for narrow leafed seedlings in any series to have richer juice, this does not preclude the occasional occurrence of excellent seedlings among the broader leafed classes. It is possible that these irregularities may be due to faults in analysis or in observation, as suggested above, but they may be intrinsic, and we have at present no means of determining their cause. Naturally, the greatest reliance is placed on the larger series (*Chittan* and *Karun*) and it is not certain what is the lowest number of seedlings in which true correlations may be expected. Probably this varies with the different characters under consideration but, taking the whole series of observations, it is considered that 40 or 50 seedlings will usually be sufficient, but that smaller numbers than these are liable to errors, which, however, can usually be detected on inspection by the occurrence of isolated abnormal seedlings in their wrong place. This has been easily observable in the small *Poovan* lot, where one seedling, with 20·40% sucrose in the juice, towered above the rest and, to a certain extent, dominated the results according to its position.

In order to make the general method of calculation clear, it has been thought advisable to give the details of one correlation studied, and I have

selected, at random, that between leaf width and sucrose in *Karun* seedlings, and I have gone into this in some detail in order to indicate some of the difficulties encountered in the work. Arranging the whole 322 *Karun* seedlings in order of leaf width, it was found that they fell into 20 classes differing from one another by one-tenth of an inch, and ranging in width between 1·5″ and 3·6.″ The best sucrose reading obtained in petty or bulk analysis was placed opposite each seedling and averages were struck for each class of common leaf width. The following was thus obtained :—

Leaf width and sucrose in Karun seedlings.

Leaf width	No. of seedlings	Total sucrose in the juice	Av. sucrose per seedling
1·5″	1	15·69	15 69
1·6″	3	48·78	16 26
1·7″	3	49·25	16·42
1·8″	12	182·39	15·20
1·9″	9	69·42	15·20
2·0″	20	299·23	14·96
2·1″	35	532·15	15·20
2·2″	37	542·58	14·66
2·3″	41	621·20	15·15
2·4″	34	509·29	14·93
2·5″	37	537·29	14·52
2·6″	28	412·60	14·74
2·7″	25	379·37	15·17
2·8″	11	167·92	15 27
2·9″	12	171·45	14·29
3·0″	6	91·82	15·30
3·1″	4	51·46	12·86
3·2″	2	27·76	13·58
3·3″	1	12·36	12·36
3·6″	1	10·64	10·64

The figures in column 2 of the table present together a fairly normal frequency curve (*cf.* p. 142), and it may be noted that in column 4 the higher sucrose values are more or less collected in the upper half of the table. But the importance of these values in the general average is regulated by the number

opposite to each in column 2, namely, the number of seedlings having that sucrose reading, and, in order to see the general tendency, it is necessary to contract the series of classes considerably. The whole have accordingly been collected into four and two classes, and this has been done in two different ways.

(1) The list has been arranged in four (and two) equal classes, these classes having the same number of seedlings in order of leaf width. The following classes are thus obtained :—

Classes		Number of seedlings	Range of leaf width	Total sucrose in the juice	Average sucrose
Four equal classes (as regards numbers)	1	80·5	1·5″—2·1″	1,226·29	15·24
	2	80·5	2·1″—2·3″	1,201·78	14·94
	3	80·5	2·4″—2·6″	1,186·61	14·74
	4	80·5	2·6″—3·6″	1,185·35	14·73
Two equal classes (as regards numbers)	1	161	1·5″—2·3″	2,428·07	15·08
	2	161	2·4″—3·6″	2,371·96	14·73

(2) The list has been arranged in four (and two) classes, this time separated by equal differences in leaf width. The four classes obtained in this way are of unequal size, the first and last being smaller, that is, having fewer seedlings in them than the second and third. The value of this classification will obviously depend on whether the end classes are sufficiently large for fair averages to be obtained.

Classes		Number of seedlings	Range of leaf width	Total sucrose in the juice	Average sucrose
Four classes according to differences in leaf width	1	48	1·5″—2·0″	732·14	15·25
	2	184	2·0″—2·5″	3,041·74	14·91
	3	82	2·6″—3·1″	1,274·62	14·82
	4	8	3·1″—3·6″	102·22	12·78
Two classes	1	232	1·5″—2·5″	3,474·65	14·98
	2	90	2·6″—3·6″	1,325·38	14·73

In dividing the 322 *Karun* seedlings into equal classes according to numbers, a fraction is introduced, and this becomes more inconvenient if it is $\frac{3}{4}$ instead of $\frac{1}{2}$, as it would be if there were 321 seedlings instead of 322, and it has been usually found simpler, when the total number of seedlings is not divisible by four, to allow the classes to overlap, this being done symmetrically. Thus, if there were 321 seedlings, each of the classes would be made to overlap one, that is, the last of the first class would be repeated and taken as the first of the second class, and so on. There would thus be three seedlings repeated and we should have four classes of 81 each. Similarly, when there are 322,

the first and second classes and the third and fourth would overlap and, when there are 323, the second and third only, in each case bringing the classes each to 81 seedlings. This method does away with the fraction which introduces difficulties in calculation and, in dealing with large numbers, has no advantage. By using the method of overlapping, in classes of equal numbers there will never be an excess of seedlings over the actuals of more than three.

In the second method, that of dividing the list into classes with equal differences in leaf width, on the other hand, the matter is not so simple. If overlapping is resorted to, it will not be of individuals but of *classes* and the number of seedlings will sometimes be considerably increased, according to the numbers in the repeated classes. The number of classes in the general list of *Karun* seedlings is 20, but we cannot simply divide these into four classes of five each because they are not of equal leaf width differences. The extremes are 1·5″ and 3·6″, thus making 22 classes separated by one-tenth inch in leaf width, the two classes 3·4″ and 3·5″ having no representatives. In dividing these into four classes according to leaf width, two must overlap, giving the four groups 1·5—2·0″, 2·0—2·5″, 2·6—3·1″ and 3·1—3·6″. It is obvious that there are objections to this overlapping, but the method appears, on the whole, to work satisfactorily. The two classes which are repeated have, between them, 24 seedlings, and the number of seedlings in the four classes is thus 346 instead of the correct number 322. It all depends on whether the repeated classes are likely to alter the general results, and this is one reason for the inclusion of the division into two classes as well, for then the class repeated, if there is one, will be a different one. In the case in point, class 2·0″ (with 20 seedlings) has 14·96 sucrose, which is fairly average, but class 3·1″ (with 4 seedlings) is distinctly low, but there are too few seedlings in the latter class to make much difference. Each case must be thus judged on its merits, and one is given on p. 189, where the repetition of classes has introduced a discrepancy, because the classes repeated are both exceptional and of sufficient size to influence the results. This is at once checked by the divisions into two classes and such cases give additional weight to the advisability of studying these correlations by the two methods described above.

From a consideration of the table of *Karun* seedlings, it is seen that there is a distinct tendency for the narrow leafed forms to have richer juice (as judged by the sucrose contained) than the broader leafed forms, in other words, that there is a negative correlation between leaf width and sucrose. But this by no means excludes the occurrence of good seedlings among the

broad leafed plants. Taking the whole series of seedlings and selecting the five best and five worst seedlings, we have the following :—

	No. of seedlings	Leaf width	Sucrose % in juice	Glucose % in juice
The five *Karun* seedlings with highest sucrose ...	907	1·9″	19·85	0·13
	973	2·1″	19·28	0·71
	1,199	2·3″	19·09	1·35
	1,098	2·2″	19·07	0·50
	1,033	2·7″	19·01	0·93
The five *Karun* seedlings with lowest sucrose ...	1,278	2·2″	10·34	1·16
	952	3·6″	10·64	1·56
	1,130	1·9″	10·74	1·43
	998	1·8″	10·81	2·00
	1,039	2·2″	10·86	2·17

These figures are interesting in several respects and deserve careful consideration. The average leaf width of the whole series of *Karun* seedlings is 2·4″ and, if we exclude, in selection, all seedlings with wider leaves than this we may lose a very good one, for instance No. 1033. On the other hand, the seedling with narrowest leaves in these ten has only 10·81% sucrose. The glucose in the low sucrose class is much higher than in the high sucrose class, as might have been expected, but it is a question whether some of the former have not been hardly treated, in that they may have been unripe at crop time. Lastly, the seedling which had the widest leaves in the whole 322 seedlings, No. 952, and which had received marked attention throughout its growth because of this, was lowest of all but one in sucrose, and all the seedlings with widths over 3·0″ were very poor. This is an example of a fact not infrequently recurring in these studies, namely, that a seedling which differs markedly from the rest is often of very poor character as regards its juice. The extremes in any series, chiefly such as are of unusually large dimensions are generally more or less worthless.

As I have stated above, the selection of this correlation in the *Karun* seedlings for detailed analysis was made purely at random, and facts similar to those here noted may be met with in any of the larger series dealt with in the paper. It is hoped that discrepancies such as those noted may be ruled out by more careful selection, as regards growth and maturity, in the further sets of seedlings as they reach the stage when chemical analysis is possible, but there is no disguising the fact that irregularities are bound to occur, however much care is thus taken.

LEAF WIDTH AND SUCROSE.

Correlation 1.

The correlations thus far investigated will now be dealt with in succession, commencing with that between leaf width and sucrose. It is a well recognised fact that, while more or less profound differences in the floral organs are found necessary for the classification of plants, it is to the minute differences in the vegetative organs that the plant breeder looks for indications of character. Small differences in the width of leaves, otherwise entirely similar, fall under the latter category. These are easily marked in any batch of seedlings and, from the fact that the broader leafed forms more nearly approach the thicker, richer, tropical canes, they have attracted attention from the very beginning. Between 1,100 and 1,200 seedlings have now been measured for leaf width at crop time. In growing plants, as has been stated above, probably the best method of determining the average width of the leaves in any seedling is to observe the general appearance of the plant at a short distance, and then to measure what appears to be an average leaf carefully. This method is called "eye measurement," but, at maturity, it has not been found possible to apply it. The plants have grown too high for accurate judgment and the leafy shoots are frequently battered by the weather. The following method has accordingly been adopted. Ten healthy shoots are cut and laid out. In each of these the broadest leaf is selected and measured at its broadest part, and an average is then struck between the ten measurements obtained. The factor here dealt with is therefore less the average leaf width than the maximum, the greatest leaf width of the seedling at crop time. The method of dividing the seedlings into classes has been described in detail for the *Karun* series and, in the table appended, summaries are recorded for all the batches of seedlings measured. In this and the following correlations the classes are arranged in ascending order, commencing with narrowest, shortest, thinnest, etc., and passing regularly to the widest and so on. *Chittan, Karun, Kaludai Boothan, Saretha* and *Cheni* agree in showing a very distinct negative correlation between leaf width and sucrose in the juice. In the small class of *Poovan* seedlings, this correlation is reversed, because of the errant position of the

single seedling, No. 1810, with 20·40% sucrose. It might be considered better to avoid the inclusion of this series in the tables that follow, but it has been retained in order to help us in judging the lower limits of numbers which can be safely employed, and the nature of the error met with in dealing with very small numbers.

These are all general collections in which the father is not definitely known. The *Naanal* seedlings, also a general collection, do not fall into line, although some seventy in number. In fact, the correlation, although somewhat irregular, is distinctly positive. A tendency in the same direction is traceable in *Vellai* × *Saccharum Narenga* and, to a less extent, in *Shakarchynia* × *Saccharum spontaneum*, all the members of which two series are undoubted crosses. This fact tends to support the suggestion that the *Naanal* seedlings of 1912-14, purporting to be a general collection, may be comprised, to a certain extent, of crosses, some of which show a strong resemblance to *Saccharum spontaneum*. It is also, however, worth noting that the general series, with the probable exception of the small *Cheni* class, are thick canes, whereas *Naanal* is an indigenous Indian one, the only one besides *Cheni* belonging to this class in the seedlings measured. It is, namely, possible that the thicker tropical canes differ in these correlations from the Indian canes. Be that as it may, the difference in behaviour between the general collections and the crosses is interesting and will be met with in several other cases. It has suggested itself that the deviation of the *Naanal* results, from those obtained for *Karun*, *Chittan* and other general collections, might be caused by the inclusion of the six aberrant forms noted on page 134, as all of them had markedly low sucrose content and very narrow leaves. Figures have accordingly been prepared for the *Naanal* seedlings in this and other tables in two ways, firstly, by taking all the seedlings and, secondly, by eliminating the six seedlings resembling *Saccharum spontaneum*. The general results in the two sets of correlation figures obtained are, however, more or less similar.

LEAF WIDTH AND SUCRSOE.

	Number of seedling	[1]Equal classes as to numbers of seedlings						[1]Classes of equal differences in leaf width						Correlation
		Two classes		Four classes				Two classes		Four classes				
Chittan	492	14·89[2] 249	14·42 243	14·94 125	14·84 124	14·55 124	14·29 119	14·80 293	14·43 199	15·33 37	14·74 256	14·50 162	14·13 37	−
Karun	322	15·09 161	14·73 161	15·24 80·5	14·94 80·5	14·74 80·5	14·73 80·5	14·98 232	14·73 90	15·25 48	14·91 204	14·82 86	12·78 8	−
Kaludai Boothan ...	57	13·98 28	13·38 29	14·57 14	13·40 14	13·78 15	12·99 14	13·77 31	13·60 25	14·66 7	13·51 24	13·80 20	12·78 5	−
Saretha	44	14·88 22	14·16 22	15·34 11	14·42 11	14·07 11	14·26 11	15·17 28	12·79 16	15·40 6·5	15·07 21·5	13·70 13·5	12·95 2·5	−
Saretha (Leaf-width judged by eye.)	48	14·81 24	14·15 24	15·17 12	14·56 12	14·21 12	14·09 12	... ...	... ...	... ...	... ...	... ...	... ...	−
Cheni	16	13·04 8	11·83 8	... ...	... ...	... ...	... ...	12·9 10	11·6 6	... ...	... ...	... ...	... ...	−
Poovan	12	15·17 6	16·85 6	... ...	... ...	... ...	... ...	15·23 8	15·85 4	... ...	... ...	... ...	... ...	+
Naanal (all)	71	10·30 36	10·91 36	9·67 18	10·94 18	10·90 18	10·93 18	9·77 ...	10·91 ...	8·97 6	10·45 19	10·90 40	10·95 6	+
Naanal (*Saccharum spontaneum* class left out.)	65	10·58 34	10·92 34	10·14 17	11·03 17	10·90 17	10·94 17	10·45 22	10·92 43	9·85 9	10·87 13	10·99 37	10·46 6	+ ?
Shakarchynia × *Sacch. spont.*	62	9·68 31	9·69 31	9·74 16	9·61 15	9·73 15	9·66 16	9·64 31	9·69 31	9·80 8·5	9·58 22·5	9·70 26	9·65 5	0
Vellai × *Sacch. Narenga*	81	11·52 42	11·88 42	11·47 21	11·57 21	11·90 21	11·87 21	11·24 40	11·81 54	11·40 11	11·18 29	11·89 39	11·61 15	+ ?

[1] The classes in this and the following tables are arranged in ascending series, commencing with the lowest measurement figure of the character being compared with sucrose.

[2] The upper figure indicates sucrose in the juice, the lower figure the number of seedlings in the class.

LENGTH OF LEAF AND SUCROSE.

CORRELATION 2.

This correlation calls for little remark. The length of leaf was obtained in exactly the same manner as the leaf width, in fact the same shoots were measured in the two cases. In all the classes examined, excepting one, there is a distinct negative correlation between leaf length and sucrose in the juice. The exception is the cross between *Vellai* and *Saccharum Narenga*, again a series of crossed seedlings. The absence of divisions into four classes in the smaller series is due to great irregularities in these, the full lists of seedlings arranged according to length of leaf, not falling readily into normal frequency curves as they did in the leaf width series.

LENGTH OF LEAF AND SUCROSE.

	Number of seedling	Equal classes as to numbers of seedlings						Classes of equal differences in length of leaf						Correlation
		Two classes		Four classes				Two classes		Four classes				
hittan	491	14·87	14·43	15·01	14·73	14·46	14·41	14·86	14·44	14·65	14·88	14·51	14·42	–
		245	246	123	122	123	123	276	244	26	250	216	26	
Karun	324	15·01	14·79	15·21	14·81	14·99	14·59	15·08	14·68	15·31	15·01	14·69	14·64	–
		162	162	81	81	81	81	203	159	52	151	137	22	
Kaludai Boothan ...	57	14·25	13·09	...	...	...	...	14·09	13·03	...	...	...	...	–
		29	29	...	...	...	...	35	22	...	...		...	
Saretha	48	14·97	14·18	...	...	...	...	15·08	14·33	...	...	...	...	–
		24	24	...	...	...	...	15	33	...	...	...	...	
Cheni	15	12·34	12·03	...	...	...	...	...	...	...	...	...	...	–
		8	8	...	...	...	...		...	...	...	...	...	
Poovan	13	15·64	15·13	...	...	...	...	...	...	...	...	...	...	–
		7	7		...	...	...	...	...	...	...	...	...	
Vellai × *Sacch. Narenga*	81	11·45	11·84	11·49	11·41	11·96	11·72	12·10	11·62	12·57	11·83	11·51	11·80	0
		42	42	21	21	21	21	11	70	4	7	43	27	
Naanal (*Saccharum spontaneum* class left out.)	65	11·09	10·45	...	...	...	...	11·09	10·45	...	...	...	...	–
		32	33	...	...	...		32	33	...	...	...	...	
Naanal (all)	71	10·96	10·24	...	...	...	...	10·98	10·24	...	...		...	–
		36	36	...		...	...	35	36	...	...	...	...	

LEAF MODULE AND SUCROSE.

Correlation 3.

The leaf module, as explained in the section on Variation in Morphological Characters, is the average extreme leaf length divided by the average extreme leaf width, a factor noted in a previous paper[1] as of some value in distinguishing North Indian canes. In the general collection series there is a distinct positive correlation between leaf module and sucrose. The series is however marred by the *Karun* seedlings, where the curve is irregular, owing to the high sucrose content in two classes early in the list, and there is thus only a tendency towards a positive correlation. The crosses again agree in differing from the rest, which is not surprising, in that the present correlation is a combination of the two previous ones. *Naanal* also shows a distinctly negative tendency.

[1] Barber, C. A. *Mem. Dept. Agri. India, Bot. Ser.* vol. VII, no. 1, p. 31

LEAF MODULE AND SUCROSE.

	Number of Seedlings	Equal classes as to numbers of seedlings						Classes of equal differences in leaf module						Correlation
		Two classes		Four classes				Two classes		Four classes				
Chittan	466	14·62	14·98	14·49	14·76	14·90	15·06	14·67	14·98	14·38	14·72	14·95	15·20	+
		233	233	117	116	116	117	324	196	46	278	173	23	
Karun	324	14·90	14·92	15·07	14·74	14·83	15·01	14·89	14·94	13·89	14·99	14·85	15·39	+ ?
		162	162	81	81	81	81	181	142	17	164	118	24	
Kaludai Boothan ...	55	13·48	14·09	...	..	...	...	13·48	14·09	...	...	...	...	+
		28	28	...	...	...	...	28	28	...	...	...	...	
Saretha	39	14·19	15·08	...	...	...	...	14·22	15·14	...	...	...	...	+
		20	20	...	...	...	...	21	18	...	...	...	...	
Cheni	15	12·08	12·66	...	...	...	...	12·11	12·44	...	...	...	..	+
		8	8	...	...	...	...	9	6	...	...	...	...	
Poovan	13	15·31	15·88	...	...	...	...	15·75	14·02	...	...	...	...	0
		9	9	...	...	...	...	11	7	...	...	...	...	
Naanal (all)	71	11·11	10·13	10·80	10·86	10·02	10·24	10·73	9·23	10·85	10·47	10·99	7·38	–
		36	36	18	18	18	18	65	6	45	20	3	3	
Naanal (*Saccharum spontaneum* class left out) ...	65	11·21	10·36	11·40	10·91	9·86	10·90	10·68	10·54	...	...	...	...	–
		33	33	16	16	17	16	50	20	...	...	...	...	
Vellai × *Sacch. Narenga*	81	11·94	11·45	11·90	11·99	11·57	11·33	11·81	11·38	11·44	11·91	11·32	11·80	–
		42	42	21	21	21	21	52	34	11	41	30	4	

THICKNESS OF CANE AND SUCROSE.

Correlation 4.

The method of measuring the thickness of the cane has undergone a good many changes before a satisfactory one has been hit upon. At first ten or more canes were laid out and measured at the base, at the middle and at the highest mature joint (judged by hardness of rind). Measurements were also taken in two directions, namely, in the plane of the buds and at right angles to it. The latter, however, was soon discarded as, in reality, merely a measure of the ovalness in section, inherent in all sugarcanes. But these measurements even then were altogether too cumbrous in any large series and, after some changes, the following plan was adopted. All the canes of a seedling at crop time were laid out on a table and an average one was selected by eye measurement. This was then measured by calipers at the middle in the plane at right angles to the line of buds. The correlation is thus between the thickness of an average cane at middle and sucrose in the juice. The results are conflicting, and possibly no true correlation exists. But, in the general series, there is a somewhat marked negative tendency in most cases. The crosses, on the other hand, and *Naanal*, show the opposite tendency, namely, to a positive correlation. This may be in accordance with the fact that the thick stemmed parent is vastly richer in sucrose than the wild form with which it has been crossed. On the whole, beyond these tendencies, no definite correlation can be said to have been established between cane thickness and sucrose.

THICKNESS OF CANE AND SUCROSE.

	Number of seedlings	Equal classes as to numbers of seedlings.						Classes of equal differences in thickness of cane						Correlation
		Two classes		Four classes				Two classes		Four classes				
ittan	4	14·73 231	14·73 231	14·87 115	14·60 116	14·86 116	14·61 115	14·74 228	14·74 274	14·55 27	14·76 201	14·74 185·5	14·74 48·5	0
Karun	317	15·01 160	14·87 160	15·38 80	14·64 80	15·19 80	14·56 80	15·01 169	14·86 148	15·39 32	14·92 137	14·96 122	14·41 26	–?
dai Boothan ..	54	13·81 27	13·71 27	13·82 13·5	13·80 13·5	13·82 13·5	13·60 13·5	13·85 44	13·73 33	13·79 13	13·88 31	13·79 23	13·58 10	–?
Saretha	43	14·79 21·5	14·74 21·5	15·08 10·75	14·50 10·75	14·55 10·75	14·94 10·75	14·63 17	14·55 26	15·49 3·75	14·39 13·25	14·37 20	15·14 6	–?
Saretha (classes overlapping).	43	... ...	... ...	... ...	... ...	... ...	... ...	14·50 23	14·43 33	15·34 6	14·21 17	14·23 24	14·95 9	
Cheni	16	13·01 8	11·86 8	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	–
Poovan	11	15·11 6	16·92 6	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	+
Naanal (all) ..	71	10·43 36	10·79 36	9·86 18	11·00 18	10·68 17	10·89 18	9·15 11	10·87 60	... ...	9·13 11	11·10 30	10·75 30	+?
Naanal (*Saccharum spontaneum* class left out) ...	65	10·71 33	10·81 33	10·40 16	11·00 17	10·65 16	10·95 16	10·73 36	10·79 29	... ...	9·39 6	11·00 30	10·82 29	+?
Shakarchynia × *Sacch. spont.*	...	9·30 31	9·50 31	9·15 15·5	9·45 15·5	10·28 15·5	9·78 15·5	9·50 59	9·96 40	9·16 20	9·14 39	10·02 31	9·77 9	+?
Vellai × *Sacch. Narenga* ...	...	11·52 44	11·83 44	11·28 22	11·76 22	11·80 22	11·86 22	11·54 58	11·22 29	11·10 16	11·71 42	12·01 22	11·64 7	+

LENGTH OF CANE AND SUCROSE

Correlation 5.

The length of the cane was usually determined by taking ten or more canes out of the cut crop, measuring them accurately and striking an average of the ten. The canes were not measured until all the leaves had been stripped off, so that the total length above ground was easily obtained. The correlation is therefore between the average length of cane above ground (or height of cane) and sucrose. On the whole there seems to be a general tendency for the taller canes to have more sucrose. The matter is not, however, very convincing, in the absence of a marked correlation, because it is probable that ill grown seedlings, which would be of poor stature, would naturally give poor juice. This was certainly the case with the *Cheni* seedlings of 1911-13, all of which were analysed at crop time irrespective of extremely poor growth in some of them. The differences in sucrose are not very great between the extreme classes in the table. There is, however, one feature which deserves attention. In many cases (especially the larger series of *Chittan* and *Karun* seedlings), while the first three classes show a distinct rise in sucrose with increasing length, there is a fall in the fourth class of longest canes. This occurs in at least one of the classifications of each set of seedlings, where four classes have been possible, that is in all the sets excepting the small lots of *Cheni* and *Poovan*. It may therefore be postulated that the very tall canes, as a class, are distinguished by having less sucrose than those of moderate height, and, if we rule out this fourth class, there is a distinct positive correlation between length of cane and sucrose.

LENGTH OF CANE AND SUCROSE.

	Number of seedlings	Classes in equal numbers						Classes of equal differences in length of cane						Correlation
		Two classes		Four classes				Two classes		Four classes				
Chittan	451	14·31 226	15·31 225	13·97 113	14·65 113	15·47 113	15·14[1] 112	14·69 340	15·13 111	13·99 130	15·13 210	15·17 102	14·69[1] 9	+
Karun	330	14·57 165	15·25 165	14·00 82·5	15·15 82·5	15·40 82·5	15·10[1] 82·5	14·53 178	15·22 152	13·86 32	14·68 146	15·27 129	14·95[1] 23	+
Kaludai Boothan ..	54	13·45 27	13·99 27	13·21 13	13·68 14	14·34 14	13·61[1] 13	13·80 38	13·67 17	12·98 9	14·05 29	13·61 12	13·80 5	+ ?
Saretha	49	14·49 24	14·82 25	14·93 12	14·05 12	14·98 13	14·65[2] 12	14·36 43	14·38 7	14·49 24	14·99 19	15·18 4	13·31[1] 3	+ ?
Cheni	19	11·96 10	12·99 10	... ...	... ...	... ...	... ...	11·99 12	12·86 8	... ...	... ...	... ...	... ...	+
Poovan	14	14·94 7	16·00 7	... ...	... ...	... ...	... ...	15·62 8	15·27 6	... ...	... ...	... ...	... ...	0 ?
Naanal (all)	85	10·57 43	10·45 43	10·62 22	10·52 22	10·82 22	10·10[2] 22	10·54 53	10·46 32	11·15 6	10·42 47	11·23 16	9·68[2] 16	0 ?
Naanal (*Saccharum spontaneum* class left out).	79	10·71 40	10·55 39	10·66 20	10·75 20	11·03 19	10·09[1] 20	10·71 49	10·50 30	11·15 6	10·64 43	11·32 15	9·67[2] 15	0 ?
Shakarchynia × *Sacch. spont.*	67	9·52 34	9·67 34	9·39 17	9·64 17	9·71 17	9·64[1] 17	8·62 12	9·63 73	6·55 1	9·35 11	9·67 43	9·57[1] 30	+
Vellai × *Sacch. Narenga*	87	10·81 44	12·36 44	10·68 22	10·95 22	12·52 22	12·21[1] 22	10·79 33	12·37 44	10·93 10	10·73 33	12·32 32	12·50 12	+

[1] Steady rise for first three classes and then a drop in the fourth.
[2] No steady rise, but third class highest.

CANE MODULE AND SUCROSE.

Correlation 6.

The module of the stem, as in the leaf, is the length divided by the thickness, but the resultant is one of averages and not of extremes as in the leaf measurements. There is a distinct positive correlation between cane module and sucrose in the larger series, *Chittan* and *Karun*, which is all the more to be noted when we remember the irregularities in the two preceding tables. The others of the general series fall more or less into line, excepting *Cheni*, whose length measurements have, however, been already stated to be untrustworthy (p. 180). It is noteworthy that the *Vellai* cross disagrees with its allies on other occasions, *Naanal* and the *Shakarchynia* cross, and shows a distinctly positive correlation. On the other hand, the two latter agree remarkably, in each case with a maximum in the second class followed by a decline in the third and fourth, a feature of perhaps no importance and merely a coincidence, but worthy of note in passing.

The measurements of leaf and stem have now been fairly fully studied in their relation to the quantity of sucrose in the juice. From this study it would appear that the seedlings, in any general collection, with higher sucrose content, would be marked out by rather narrow, short leaves, but with a relatively high leaf module, with canes which might be thick or thin but with a leaning towards the thin side, rather long but not very, and with a moderately high cane module. Where the seedlings are the result of a definite cross between two different species of Saccharum, these rules do not hold good. In fact, we should, according to the tables, look in these crosses for higher sucrose in thicker canes with broader leaves, but the results with the other factors are not clear and are contradictory among themselves, and we need more cases before any definite conclusions can be arrived at. It is probable that the tendencies will depend on the peculiarities of the parents in each separate case. The *Naanal* seedlings are an enigma, generally behaving as if they were the result of a cross, and it may be that, in these correlation studies, we may find a means of detecting whether any batch of seedlings is a general collection largely selfed or a set of crossed seedlings.

The leaf width being very easily measured, and having given good results thus far, it has been thought worth while to compare it with certain other characters, namely, thickness of stem, total weight of seedling at crop time and tillering power, the latter two bearing independently on the vigour of the cane.

CANE MODULE AND SUCROSE.

	Number of seedlings	Equal classes as to numbers of seedlings						Classes of equal differences in cane module						Correlation
		Two classes		Four classes				Two classes		Four classes				
Chittan	453	14·39	15·47	13·84	14·93	15·07	15·47	14·59	15·43	13·76	14·94	15·56	15·00	+
		227	227	113	114	113	114	334	119	99	235	93	26	
Karun	329	14·59	15·14	14·27	14·92	14·98	15·30	14·66	15·31	14·03	14·89	15·25	15·60	+
		164	165	82	82	82	83	244	93	65	179	76	17	
Kaludai Boothan ...	51	13·60	13·87	13·33	13·89	13·84	13·90	13·49	14·05	14·09	13·33	13·99	14·23	+ ?
		25	26	13	12	13	13	33	20	7	26	15	5	
Saretha ...	48	14·59	15·45	14·79	14·40	15·83	15·06	14·58	14·93	15·35	14·28	15·15	14·45	+ ?
		24	24	12	12	12	12	29	19	8	21	13	6	
Cheni	18	12·55	12·09	...	...	...	...	12·67	11·52	...	...	...	...	–
		9	9	...	...	...	...	12	6	...	...	...	...	
Poovan	14	13·45	15·01	...	...	...	...	13·48	15·60	...	...	...	...	+
		7	7	...	...	...	...	9	5	...	...	...	...	
Naanal (all)	84	10·91	10·12	10·89	10·94	10·37	9·88	10·97	10·15	10·98	10·97	10·58	9·25	–
		42	42	21	21	21	21	38	46	5	33	31	15	
Naanal (*Saccharum spontaneum* class left out).	78	10·97	10·31	10·90	11·04	10·35	10·26	11·00	10·31	10·98	11·00	10·58	9·48	–
		39	39	19	20	20	19	37	41	5	32	31	10	
Shakarchynia × *Sacch spont.*	80	10·08	9·55	9·69	10·47	9·85	9·25	9·98	9·58	9·18	10·23	9·74	9·25	–
		40	40	20	20	20	20	41	62	9	32	42	20	
Vellai × *Sacch. Narenga*	85	11·40	11·89	11·11	11·70	11·55	12·24	11·30	12·08	11·18	11·34	11·91	12·85	+
		44	44	22	22	22	22	55	33	16	39	27	6	

LEAF WIDTH AND THICKNESS OF CANE.

Correlation 7.

It is natural to assume that thick canes will have broad leaves, but the results of our studies have not always turned out as we expected them to, as in the case of leaf width and sucrose, where it was at first thought that the wider leafed forms, resembling the thicker canes of the tropics would have better juice. It is true that, the thicker the stem, the wider the base for leaf attachment; but we have noted in our study of the Punjab canes[1] that near relatives vary as to the extent to which the base of the leaf ensheathes the stem, and also that the relative width of lamina and leaf sheath varies a good deal at the point of junction. No help can be got from the previous tables where both the leaf width and stem thickness give or tend to give negative correlation with richness of juice. It was thought worth while, accordingly, to test the matter, and the results are given in the accompanying table. From its study we see that there is a very definite positive correlation between leaf width and thickness of cane. This is seen in all the seedlings of the general collection and in the *Vellai* cross. But in the other cross there is merely a tendency to a positive correlation and the differences in thickness in the classes of leaf width is remarkably small. In the *Naanal* seedlings, on the other hand, there is no trace of correlation either way, the whole of the classes varying slightly in an irregular manner, another case in which these puzzling seedlings are at variance with the other general collections. The *Poovan* seedlings are too few for any distinct correlation to be discernible.

[1] Barber, C. A. *Mem. Dept. Agri., India, Bot. Ser.* vol. VII, no. 1, p. 28.

LEAF WIDTH AND THICKNESS OF CANE.

	Number of seedlings	Equal classes as to numbers of seedlings						Classes of equal differences in leaf width						Correlation
		Two classes		Four classes				Two classes		Four classes				
Chittan	473	2·9[1]	3·4	2·8	3·1	3·3	3·5	3·0	3·4	2·8	3·1	3·4	3·6	+
		236	237	118	118	119	118	363	209	74	289	174	35	
Karun	318	3·0	3·5	2·9	3·1	3·4	3·7	3·1	3·7	2·7	3·2	3·6	4·1	+
		159	159	79·5	79·5	79·5	79·5	192	126	29	163	112	14	
Kaludai Boothan ...	56	3·1	3·3	2·9	3·3	3·2	3·4	3·1	3·4	2·8	3·2	3·3	3·6	+
		28	28	14	14	14	14	32	24	8	24	19	5	
Saretha	43	1·6	1·8	1·5	1·8	1·8	1·9	1·7	1·9	1·5	1·8	1·8	2·1	+
		22	22	11	11	11	11	27	16	9	18	13	3	
Cheni	18	1·7	2·2	...	...	...	...	1·8	2·2	...	...	...	...	+
		9	9	...	...	...	...	11	5	...	...	...	...	
Poovan	11	3·1	3·0	...	...	...	...	3·0	3·4	...	...	...	...	0
		6	6	...	...	...	...	8	3	...	...	...	...	
Naanal (all)	71	Classes varying from 1·4 to 2·8, these variations being found in the *Sacch. spont.* class of six seedlings. The general result is the same whether these are included or omitted, and there is no correlation observable, all the averages being practically the same.												0
Naanal (*Saccharum spontaneum* class left out).	65	Classes varying from 2·1 to 2·2 irrespective of leaf width.												0
Shakarchynia × *Sacch. spont.*	62	1·1	1·2	1·1	1·1	1·2	1·2	1·1	1·2	1·1	1·1	1·2	1·2	+ ?
		31	31	15·5	15·5	15·5	15·5	47	45	16	31	34	11	
Vellai × *Sacch. Narenga*...	79	1·7	1·9	1·6	1·8	1·9	2·0	1·7	1·9	1·5	1·7	1·9	2·0	+
		40	40	20	20	20	20	37	54	10	27	39	15	

[1] The lower figures indicate, as before, the number of seedlings dealt with and the upper figures give thickness of cane in centimetres.

LEAF WIDTH AND TOTAL WEIGHT OF SEEDLING.

Correlation 8.

The total weight of the seedling, one of the factors by which the vigour of growth may be judged, is taken only of those parts which are above ground, —all the canes and shoots at crop time. To get this figure requires a certain amount of management. In petty analyses canes are cut and they and their leaves are lost, while at harvest certain of the canes are not infrequently dried up or injured, introducing elements of doubt. Allowances have been made with regard to these facts. Even after this has been done, one would be prepared for the absence of definite results. But a study of the table will show that these doubts are unfounded, and there seems to be a very definite positive correlation between the width of the leaf and the total weight at harvest. This is perhaps what would have been expected, but it must be remembered that the narrow leafed North Indian canes have vastly greater tillering power than the thicker tropical ones, and consequently many more canes in the clump. We shall see how this factor comes out in the next table. In *Naanal* and the *Shakarchynia* cross there is a rather curious deviation, in that the first and last classes are the heaviest and the two middle ones considerably lighter, a fact which would not have been considered worthy of note, but for the unexpected agreement in the two sets of figures. The *Vellai* cross agrees with the general collection series and the positive correlation is very distinct.

LEAF WIDTH AND TOTAL WEIGHT.

	Number of seedlings	Equal classes as to numbers of seedlings						Classes of equal differences in leaf width						Correlation
		Two classes		Four classes				Two classes		Four classes				
Chittan	524	41[1]	45	37	45	45	46	42	46	34	43	45	50	+
		262	262	131	131	131	131	361	214	39	271	176	38	
Kaludai Boothan ...	46	40	55	35	45	52	59	41	56	35	43	49	84	+
		23	23	11	12	12	11	26	20	6	20	16	4	
Saretha	44	42	92	35	50	76	108	50	96	32	59	94	104	+
		22	22	11	11	11	11	28	16	9	19	13	3	
Cheni	16	42	67	...	...	...	...	48	65	...	...	...	...	+
		8	8	...	...	...	...	10	6	...	...	...	...	
Poovan	11	24	43	...	...	...	...	27	55	...	...	...	...	+
		6	6	...	...	...	...	8	3	...	...	...	...	
Naanal (all)	71	104	107	116	90	94	121	108	105	145	91	100	131	0
		36	36	18	18	18	18	23	53	7	16	42	13	
Naanal (*Saccharum spontaneum* class left out).	65	95	109	97	93	94	124	...	...	...	95[2]	94	131	+
		32	33	16	16	17	16	...	...	...	22	20	13	
Shakarchynia × *Sacch. spont.*	62	99	92	111	87	79	105	99	93	113	94	88	117	0
		31	31	15·5	15·5	15·5	15·5	31	31	8·5	22·5	26	5	
Vellai × *Sacch. Narenga*	81	49	62	44	55	60	64	46	62	39	48	63	61	+
		42	42	21	21	21	21	40	54	11	29	39	15	

[1] The upper figures are total weight of seedlings in lbs

[2] Only three classes.

LEAF WIDTH AND TILLERING.

Correlation 9.

Tillering was judged by the total number of canes and shoots at crop time. Both are entered in the table, allowance being made as before for those removed during petty analyses. There is a general tendency, marked in the larger classes, towards a negative correlation between leaf width and tillering. But there is a remarkable exception in the case of the *Saretha* series, where there is a, just as strongly marked, positive correlation. This is unexplained, but it is worth while remembering that this series is practically the only one of indigenous North Indian canes, and further studies may show a difference between them and the tropical ones in this respect. It must also be remembered that it was possible to divide up the *Saretha* seedlings into habit classes (p. 133) and, on examination, it will be seen that the class with biggest seedlings had much the greatest weight and also greatest leaf width. It is possible that these habit classes, here so easily seen, dominate, and that they are absent in the thicker canes. The general result is, however, what we might expect on contrasting the tillering of tropical and North Indian canes, but the differences are much smaller than in that case. In the above remarks I have ignored the small *Poovan* class, for an examination of the tillering figures in the series shows the greatest fluctuations and the total number of seedlings is very small.

LEAF WIDTH AND TILLERING.

	Number of seedlings	Equal classes as to numbers of seedlings						Classes of equal differences in leaf width						Correlation
		Two classes		Four classes				Two classes		Four classes				
Chittan	489	14:7[1]	12:6	14:8	14:6	13:6	11:5	...	...	14:9	14:6	12:6	11:4	–
		244	245	122	122	123	122	...	...	72	296	183	38	
Karun	308	14:5	13:4	14:5	14:5	13:4	13:4	...	...	14:5	14:5	13:5	9:2	–
		154	154	77	77	77	77	...	...	48	176	77	13	
Kaludai Boothan ...	57	15·5:6·5	15:5·5	16:7	15:6	15:6	15:5	15:6	15:5	16:6	15:6	15:5	16:5	0
		28	29	14	14	15	14	32	25	8	24	20	5	
Saretha (canes and shoots together).	49	37	67	37	38	65	70	39	62	37	40	61	66	+
		24	25	12	12	13	12	21	28	5	16	21	7	
Cheni	18	47:14	41:13	...	...	...	...	49:13	37:12	...	...	...	...	–
		9	9	...	...	...	...	11	7	...	...	...	...	
Poovan	13	10:7	13:8	Great fluctuation between adjoining classes.				11:7	14:7		...	...	...	+
		7:6	7:6					8:7	8:7	...	...	...	...	
Shakarchynia × *Sacch. spont.*	62	89	73	89	88	65	81	86	74	89	84	70	87	– ?
		31	31	16	15	15	16	47	45	16	31	34	11	
Vellai × *Sacch. Narenga*	81	33:11	32:16	34:13	32:10	33:15	32:17	32:14	32:17[2]	34:12	32:15	32:16	30:19	– ?
		40	41	20	20	21	20	40	54	11	29	39	15	

[1] The upper figures are the numbers of canes : shoots, at harvest.

[2] There appears to be a discrepancy between the figures for four classes and two classes here. This is due to the overlapping. In the 1st two classes the overlapping (and repeated) figure was unusually high, while in the 2nd two classes the overlapping (and repeated) figure was unusually low (*cf.* p. 169).

COLOUR OF CANE AND SUCROSE.

Correlation 10.

The study of various other possible correlations has been commenced, but the numbers of batches of seedlings tested are not as yet sufficient for definite results to have been obtained. The measurements thus far referred to have this advantage, that there is no doubt or difficulty in preparing the lists of variation. It is otherwise with less definite characters. The universal presence or total absence of any feature is rare in any batch of cane seedlings, almost all gradations being observable. Thus, with ivory markings on the stem, the seedlings vary from those with abundant markings, through all stages, to those without any at all, and it is extremely difficult to grade them into any series. Colour has, as already stated, special difficulties, but it has been carefully observed, because of the interesting fact that a striped parent has few or no striped seedlings. The analysis given below follows the classification laid down in the section of Variation in Colour of the canes (p. 145), namely, (1) Greens without any trace of red or vinous tinge, (2) Greens with vinous or brownish tinge, (3) Purples, Reds and Clarets, (4) Striped canes. A table is appended with the comparative sucrose content in the juice for all these colours in a number of batches of seedlings, and certain facts seem to hold generally, although the *Chittans*, with striped parentage, do not agree with the rest. From the table it appears that the greens usually have the lowest sucrose, the greens with brownish tinge the highest, closely followed by those with vinous tinge.

In *Karun* (337) greens are lowest but equal vinous, purple and red, and claret and brown are distinctly highest.

In *Saretha* (selfed 50) green is distinctly lowest, then red, then vinous and brown tinged, which are highest.

In *Naanal* (84) green is distinctly lowest and brown and vinous equal and highest.

In *Poovan* (only 14) green is distinctly lowest, then vinous equals purple and red and brown are much the highest, but the numbers are too small.

In *Kaludai Boothan* (56) green is slightly lower than brown and vinous, which are equal.

In *Chittan* red is slightly highest, claret slightly lowest, green, brown, vinous and purple being practically equal (486 seedlings, with striped parent).

In *Cheni* (25) greens absorb 80% of the whole, and comparisons are not well possible.

CORRELATION BETWEEN COLOUR OF CANE AND SUCROSE.

Parents	Number of seedlings examined	Greens with no brown, vinous, red, purple, or claret	Greens with vinous tinge	Greens with brownish tinge	Red	Purple	Claret
Chittan ...	468	14·77[1]	14·63	14·76	14·96	14·66	14·24
		264	38	67	15	65	19
Karun ...	337	14·53	14·63	15·46	14·53	14·68	15·52
		147	42	30	46	16	56
Kaludai Boothan	56	13·59	13·75	13·76	11·56	...	14·47
		24	24	6	1	...	1
Saretha ..	50	14·35	14·78		14·78	..	...
		23	4		23	...	...
Poovan ...	14	13·86	15·21	18·30	17·24	15·36	...
		4	4	2	1	3	
Naanal ...	84	9·87	11·03	11·03	...	...	...
		39	17	28	...	...	...

[1] The upper figures give sucrose % in the juice, the lower figures the number of seedlings in the class.

CONCLUDING SUMMARY.

In the course of the present paper, a large number of matters of minor interest have been introduced in the course of the narrative, and certain conclusions have been arrived at with regard to them. For the benefit of those who have not the opportunity of reading the somewhat long paper through, the following summary of these conclusions is appended. For details regarding the main issues, the paper itself must be consulted, as it has been found impossible to prepare a summary of many of these, because of the great amount of detail involved. Wherever possible, this detail has been presented in the form of tables, and the paper is copiously illustrated to render the descriptions clearer.

The first piece of successful work accomplished in the newly founded Cane-breeding Station was the production of seedling canes in India. This appears to have been repeatedly attempted, and the reason for previous lack of success appears to be that almost all the efforts were made in North India. Flowering of the sugarcane is rare there, and, when it occurs, there is, generally, sterility in the male organs. Flowering, furthermore, occurs in the cold weather, when it is less likely that seedlings can be raised. The flowering of the sugarcane decreases steadily in India as we proceed north and west, until it disappears entirely. The distribution of wild sugarcanes is discussed. *Saccharum spontaneum* occurs and flowers everywhere ; *Saccharum arundinaceum* is abundant and flowers freely in Assam and is grown as far as the Punjab and Madras, but rarely flowers in these parts : *Saccharum Munja* is rare in Bengal and Assam and absent in the peninsula, but grows and flowers all along the submontane region, from Bihar to the Punjab ; *Saccharum Narenga* is quite at home in Assam, covering huge areas, and appears to extend its habitat along the base of the Himalayas. Of these, all but *Saccharum arundinaceum* flower freely on the Cane-breeding Station and crosses have been obtained between *Saccharum Narenga* and *Saccharum spontaneum* and cultivated canes.

Male sterility is judged by closed anthers, for, when these are open, the pollen is well formed, while it is only immature and filled with starch when the anthers are closed. The percentage of open anthers is determined under the lens in all the arrows dealt with, this being simpler than the former method of testing male fertility, by iodine, for the presence of starch.

Flowering at Coimbatore occurs from October to December, although later cases are often met with. A study of the best method to induce flowering has resulted in the discovery that it depends chiefly on the time of planting. The best planting time for obtaining arrows is about November, but extends in some cases to as late as March-April. As the former is not the best time for cane planting on the station, "arrowing plots" have been instituted, planted in November, and these have been attended with marked success. Certain years, however, appear to be better for arrowing than others. For protection against foreign pollen the arrows are covered by fine muslin bags outside bamboo or iron cages, much as is done in Java work. Caging must be done before emergence of the inflorescense from its sheath, as some flowers have been seen to open their anthers before protrusion. When the analysis shows few open anthers, cross pollination can be attempted but, when many anthers are open, it is probable that most of the flowers are self fertilized, and crossing has not proved successful. It seems that there is some ground for assuming prepotency of the pollen in cane flowers, although this has not been definitely settled. The season of flowering at Coimbatore is in the heart of the north-east monsoon, a period of much rain and strong winds, and this adds to the difficulties, as the slightest permanent bend in the delicate flowering stalk seems to render the ovules infertile.

The sources from which cane arrows have been obtained are various. They are abundant in the ryots' fields locally, have been obtained from Bangalore, where flowering is excellent and also from Taliparamba on the west coast and Samalkota on the east. By various means, an increasing number of canes have been induced to flower on the station itself. A very large number of North Indian canes have now been collected there, and many of these have been made to flower, some for the first time. The farm is thus gradually becoming independent, and this adds a great deal to the efficiency of control as to parentage. Pollen is now being sent from a distance by post by the use of small gelatine capsules, and appears to retain its vitality longer than expected. Sugarcane seed has also been tested and has proved to keep good for a number of months.

The treatment of the collected arrows is now stereotyped. They are chopped-up and spread over an intimate mixture of finely powdered horse

manure (cleared of its weed seeds by germination) and river sand. This is placed in shallow pans, and watered frequently through the rose of a watering can and kept in the full sun. The seedlings begin to appear on the fourth day, but have been known to germinate only after a full month. They are pricked out if growing densely but, otherwise, are left in the pans for about three months, when they are separately potted out into a mixture of sand, red earth, leaf mould and loam. At six months, they are planted in pits, arranged in 10×10 squares for convenience of study. At first, these pits were very large but, owing to the extremely luxuriant growth of the seedlings, coupled with the suspicion that this lowered their sucrose content, the pits have been gradually reduced in size and the general treatment of the seedlings made less generous. On the other hand, it has been found difficult to grow the seedlings in the second year from cuttings, as the land on the farm is not yet fully fitted for sugarcane cultivation; and the trenches in which they are planted have been gradually made deeper and the land better treated. The land on the farm is slightly saline, from having been irrigated for thirty years by brackish water, and is only gradually being got into order. Advantage has been taken of this to test varieties of sugarcane and seedling canes for capacity to resist salinity and a "saline" plot is put down each year. The usual treatment in the farm of this saline land is to give a heavy dressing of tank silt, followed by a crop of *cholam* (*Andropogon sorghum*) or *ragi* (*Eleusine coracana*) and, lastly, a green manuring crop of field bean (*Dolichos lablab*) which has been found to grow excellently in the slightly saline soil. Practically the whole of the sugarcane land on the farm has now been treated in this manner, and the improvement in the growth of the canes is very marked. Still, soil difficulties have not been the least experienced on the new farm. The early and late canes of the clump, referred to in the Memoir on Punjab Canes, have been studied in a number of varieties with the idea of reducing errors in sampling, and a series of analyses of young canes "up to dead leaf" (*i.e.*, the lower part of the cane where all the leaves have died) have been made with the object of early separating the more valuable seedlings from the worthless ones.

It takes 18 months for the seedlings to mature. Owing to the restricted period of flowering and of obtaining seed, this brings them to harvest in June—a time which is at variance with the proper reaping and planting season on the farm land. The seedlings selected on their chemical analysis are cut up and planted out but they have again to be cut up and planted when six months old to bring them into line with the local custom, which is to plant in January to March. This is also the proper time for distributing selected seedlings

to other farms. It thus takes three years before a seedling can be distributed, but it is advisable to test it for two or three years more before doing so. The cane seedlings should thus be allowed to grow on the farm for at least five years, before they are ready for distribution and testing in special localities.

The vitality of the seedlings of different parentage has been found to vary a good deal. In some cases, such as "*Java*" from Bangalore, the fertility of the arrows appears to be very great, but the seedlings are so delicate that they die in thousands when very young, and comparatively few can be grown to maturity. In others, such as *Poovan* (Coimbatore) and *Fiji C*, their later growth is weak, and the plots at crop time are mostly bare. Other varieties, such as *Saretha* (Meerut and Aligarh), produce perfectly healthy seedlings and practically any number can be raised. The seedlings obtained by crossing cultivated canes with wild grasses (*Shakarchynia*, *Chin*, *Saretha* by *Saccharum spontaneum* and *Vellai* by *Saccharum Narenga*) are characterized by excessive vigour. Their sucrose content is, of course, low, being halfway between that of the parents. They flower freely but, in most cases, the anthers are persistently closed. By crossing the best of them (with 13-16% sucrose in the juice) with thick canes it is hoped that the way may be opened for producing new good canes, presumably of very hardy nature, with wild blood in their veins. This will depend, however, on the fertility of their female organs, there being some fear that the flowers may be altogether sterile in these hybrids.

An enumeration of the various seedlings obtained each year is given in tables, together with notes as to anthesis, parentage and ultimate fate. There has been a good deal of variation in the parentage each year, owing to the particular canes flowering. The ideal constantly aimed at is to obtain crosses between the various North Indian canes and thicker, better, tropical ones, with the object of producing varieties capable of being grown in North India under ryots' conditions. Success in this respect is dependent on simultaneous flowering of the desired parents and thus far, there have been very few cases of this. The current (1915) flowering season, however, promises very well as a large number of indigenous canes and introduced tropical ones are flowering together on the farm. Most of the former have infertile stamens which is a further augury of ultimate success.

The sucrose content of the seedlings has steadily increased during the past three years, as can be seen from the table on p. 162. During the current harvesting season, the sucrose in many seedlings has been very high, and about 250 which have produced over 18% of sucrose, having been selected

for growing on. The highest figure was in a seedling raised from *B 208*, which recorded 23·4% sucrose in the juice. Owing to the heavy analytical work and unusual rains during the ripening season, harvesting has, however, extended over a very long period, and many seedlings have been analysed when their optimum had passed. This has caused us to judge the sucrose in a seedling less by its analysis at harvest (bulk analysis) than by the highest recorded, whether in petty or bulk analyses. This method will give a slightly higher series of figures than if the bulk analyses were adhered to, but there is reason to believe that the seedlings grown on the farm are handicapped, and that many of them would give higher results if planted on old sugarcane land. This is clearly indicated in a table showing the sucrose content of some Madras seedlings which were grown in a number of different localities and under different conditions of water and soil (p. 155).

The variations in the morphological characters of the seedlings have been carefully noted, with the object of correlating them with richness of juice. General habit appears to be of the greatest use in classification of seedlings, as it has proved to be with varieties of cultivated cane. But there are special difficulties in observing it in young seedlings before planting out. Much attention has been paid to erectness, as many of the North Indian seedlings develop a prostrate or creeping habit. This objectionable character has been proved to increase when the seedlings are propagated by cuttings in the second year, but they vary much in subsequent recovery during their later growth. In some, they remain permanently low and spreading, while in others there is little trace of obliqueness at crop time. The whole of the varieties of Indian canes collected on the farm have been studied as regards this habit, which appears to be hereditary, and it has been found to be much more prevalent in indigenous Indian canes than in introduced ones. Two cases are given where a seedling has been followed from the germination of the cutting to the flowering stage, and the curve of growth is illustrated by a series of photographs of the successive stages of obliqueness. (Pl. XXII.)

Tillering, colour and striping of the leaves, width of leaves and canes, etc., are likewise dealt with and variations noted in seedlings of common parentage. The possible presence of "rogues," such as are found in other cultivated crops, is discussed, and especially such as have been lately described by Bateson and Pellew in culinary peas. Some of the exceptional seedlings in general collections and crosses have been selfed and, instead of splitting up as to parental characters, they appear to produce only rogues, a fact which has caused some surprise for the last two or three years. In these studies of

morphological characters, striping of the cane has received some attention, and it is shown that the seedlings of striped canes are rarely striped, but show a large range of single colours. Striping is, indeed, extremely rare in seedlings, and when present it is connected with striping of some of the earlier leaves. It appears to arise from one-coloured canes in the form of sports, and several instances of this, which have been observed, are recorded. The well-known splitting up of striped canes when planted out into canes of the component colours is illustrated by the mention of several varieties where this habitually occurs. Of the two colours composing the striping, green is far the commoner in such one-coloured sports.

In conclusion, an attempt is made at correlating some of the morphological characters of the seedlings with richness in the juice, dealing in each case with seedlings of common parentage. It is specially important that such correlations should be detected early in the life of the seedling, so as to avoid rearing useless plants, but there are special difficulties in the way, and the principle has been adopted of trying first to find such correlations in mature canes at crop time, and later, to attempt to correlate infant and mature characters. The first step alone has been tried at present and the following correlations have been studied between mature characters and sucrose in the juice, the results being given in the summary table appended :—correlation between the amount of sucrose in the juice and various leaf and cane measurements (width, length and module, or length divided by width) and colour of cane, and correlations between leaf width and thickness of cane, tillering power and total weight of seedling. In the studies on the colour of cane, the interesting fact has come to light that, in coloured and striped canes used as parents, approximately half of the seedlings are green. This appears to be true of the coloured parents in 1912-14, although there may be a larger proportion where the parent itself is green.

COIMBATORE,

December 3rd, 1915.

SUMMARY OF CORRELATIONS.

	Chittan	Karun	Kaludai Boothan	Saretha	Cheni	Poovan	Naanal		Shakarchynia × *Saccharum spontaneum*	Vellai × *Saccharum Narenga*	Notes
Number of seedlings dealt with ...	477	323	54	46	18	13	65	71	65	80	
Leaf width and sucrose ...	−	−	−	−	−	+[1]	+?	+	0	+?	[1] The numbers are so few that a single seedling has turned the scale.
Leaf length and sucrose ...	−	−	−	−	−	−	−	−	...	0	
Leaf module and sucrose ...	+	+?	+	+	+	0	−	−	...	−	
Cane thickness and sucrose ...	0	−?	−?	−?	−	+	+?	+?	+?	+	
Cane length and sucrose ...	+[2]	+[2]	+?[2]	+?[2]	+	0	0?	0?[2]	+[2]	+[2]	[2] In 10 out of 16 cases where four classes were possible, the curve is quite distinct and peculiar. There is a steady rise in the first three classes, followed by a fall in the fourth. In 4 of the remaining 6, the third class still has the highest sucrose (*cf* p. 150).
Cane module and sucrose ...	+	+	+?	+?	+	+	−[3]	−[3]	−[3]	+	[3] In Naanal and Shakarchynia × *Saccharum spontaneum*, the curves are similar, there being a rise from the first to the second class, followed by a fall from the second to the fourth (*cf* p. 182).
Leaf width and thickness of stem	+	+	+	+	+	0	0	0	+?	+	
Leaf width and total weight ...	+	+	+	+	+	+	+	0[4]	0[4]	+	[4] In Naanal and Shakarchynia × *Saccharum spontaneum*, the first and fourth classes are much the largest and the second and third considerably lower (*cf* p. 186).
Leaf width and tillering ...	−	−	0	+	−	+	...	...	−?	−?	

POLLINATION AND CROSS-FERTILIZATION IN THE JUAR PLANT, (*ANDROPOGON SORGHUM*, BROT.)

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Introduction.

The work of classifying the varieties of *juar* grown in the Central Provinces and Berar has been in progress during the past six years. At an early stage in the enquiry evidence of natural cross-pollination was observed. It was, therefore, necessary to discover to what extent the process takes place in this crop, as not only would its occurrence account for the origin of many of the varieties, but would also militate against the successful introduction of improved varieties. The material on which the enquiry was started was the collection of *juars* from all districts in the Central Provinces and Berar sent in to the Central Provinces and Berar Exhibition of 1908.

The usual method of single plant culture was employed in order to study the characters of the plant as a preliminary to the work of classification. In the first year of cultures, evidence of natural cross-pollination was discovered. Up to the present nothing has been published in India regarding the pollination of this crop. It is proposed in the following note to give an account of the process as observed on the Nagpur Farm.

The Inflorescence.

The inflorescence in *Andropogon Sorghum* consists of a loose or congested, erect or recurved (goose-necked) panicle. On the branches of the panicle the

spikelets are arranged in pairs, a sessile hermaphrodite spikelet and a pedicelled neuter. At the apex of the branches there are three spikelets, a sessile hermaphrodite spikelet accompanied by two pedicelled neuters. These neuters represent reduced male flowers and it is the custom to describe them as male spikelets. In rare cases the male flowers are functional (Fig. 1), but for the purpose of this note they are described with regard to their usual condition and in accordance with the description in the "Flora of British India."[1]

The flowers under observation opened in a fairly regular order. The terminal hermaphrodite spikelet of the branch opened first and was followed by succeeding flowers on the branch until 3 or 4 had opened. At the same time the flowers on the adjacent and next lower branches were opening in the same order, so that we thus have the flowers near the end of the upper branches opening together during the same flowering period. On the second night when flowering recommenced the lower flowers on the upper branches opened, along with the terminal flowers on branches lower down. Flowering proceeded in this manner until all the flowers had opened. Except during the flowering period on the first night it is extremely difficult to follow the order of the opening of the flowers, as two-thirds of the panicles may be covered with flowers.

Pollination.

From the apex of the opening glumes the first essential part to appear was the tip of the stigmas. This was seen in some cases at least 24 hours before the glumes fully opened. At various hours during the night the glumes opened fully. During the months of March and April, the larger number of flowers opened between the hours of 1 A.M. and 4 A.M., but stray flowers opened as early as 11 P.M. In June and July the flowers opened mainly between 3-30 A.M. and 4-30 A.M., but on rainy nights occasional flowers opened as early as 8-30 P.M., and this continued till 4 P.M., the following afternoon.

The following tables give the numbers of flowers observed to be open. Table I records the number of flowers in 16 panicles on six successive nights from the 24th March, 1914, the total number of flowers at each period on successive nights being added together. Table II similarly records the number of flowers in 6 panicles for six successive nights from the 19th August, 1915.

[1] Hooker, J. D. *Flora of British India*, vol. VII, p. 183.

Fig. 1.

Male Pedicelled spikelet of *A. Sorghum* × 5.

The pores in the anthers are well seen.

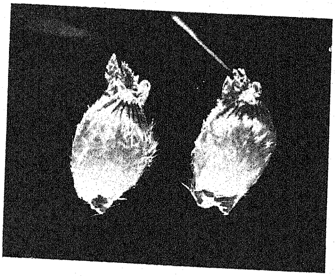


Fig. 3.

Hermaphrodite sessile spikelet of *A. Sorghum* × 5.

The anthers have dehisced without the stamens falling out.

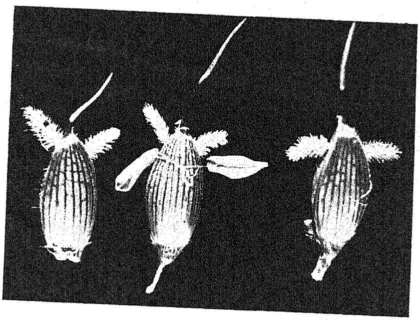


Fig. 2.

Hermaphrodite sessile spikelet of *A. Sorghum* × 5.

Glumes closed with stigmas outside and still fresh.
Photograph taken at 4 P. M.

Photo.-engraved & printed at the offices of the Survey of India, Calcutta, 1916.

TABLE I.—(March 24—29, 1914.)

Hour	No. of flowers at each period for six nights
From 11 P. M. to midnight.	358
,, midnight to 1 A.M.	1,096
,, 1 A.M. ,, 2 A.M.	1,267
,, 2 A.M. ,, 3 A.M.	1,233
,, 3 A.M. ,, 4 A.M.	1,093
,, 4 A.M. ,, 5 A.M.	797
,, 5 A.M. ,, 6 A.M.	521
,, 6 A.M. ,, 7 A.M.	443
,, 7 A.M. ,, 8 A.M.	439
,, 8 A.M. ,, 9 A.M.	214
,, 9 A.M. ,, 10 A.M.	117
,, 10 A.M. ,, 11 A.M.	46

TABLE II.—(August 19—24, 1915.)

Hour	No. of flowers at each period for six nights
From 7.30 P.M. to 8.30 P.M.	16
,, 8.30 P.M. ,, 9.30 P.M.	80
,, 9.30 P.M. ,, 10.30 P.M.	99
,, 10.30 P.M. ,, 3 A.M.	154
,, 3 A.M. ,, 3.30 A.M.	483
,, 3.30 A.M. ,, 4 A.M.	687
,, 4 A.M. ,, 4.30 A.M.	330
,, 4.30 A.M. ,, 7.30 A.M.	81
,, 7.30 A.M. ,, 4 P.M.	96

Ball [1] simply mentions that the flowers open in the morning without specifying the hour. The above observations differ from those of Koernicke[2] who finds the flowering to be at its height between 8 A.M. and 9 A.M., and states further that it may continue throughout the day. It is clear from the tables above that only occasional flowers open during the day. The latest instance of an open flower was 4 P.M. on a rainy day. The inference naturally is that the opening of the flowers is influenced by the moisture conditions of the air.

As the glumes began to open with the swelling of the lodicules, the stigmas which had been protruding slightly were seen surrounded by the three anthers. Elongation took place gradually, the tip of the stigmas still remaining above the anthers. Finally the rate of elongation of the stamens increased, the lateral stamens usually lengthening first until they surpassed the stigmas. As the pressure between the glumes was relieved by the opening of the glume and the exertion of the anthers, the anthers became more distant from each other and the lower hairs on the stigmas could be seen spreading out. The two lateral stamens finally elongated rapidly and their weight caused them to fall out. With the resulting relief of pressure the stigmas, which, up to the present, had been in the antero-posterior plane, moved into the lateral plane of the flower and rapidly expanded into the space left between the outer glumes. The posterior stamen then fell out. The dehiscence of the anthers took place at various times. Generally the lateral pores were visible just as the glumes opened, but in a considerable number of cases dehiscence took place only after the anthers

[1] Ball, C. R. *Am. Br. Mag.* 1910, p. 283.
[2] Koernicke, F. *Handbuch des Getreidebaues.*

were pendent. In a small number of flowers in the more compact type of panicle the anthers did not assume the pendent position remaining partially within the glumes close to the stigmas (Fig. 3) : while in a few of the last flowers to open for the flowering period of that night there was no dehiscence of the pendent anther. The opening of the pores of the anthers caused no scattering of pollen and it was only when the anthers had fallen over that pollen escaped. The flowers therefore are protogynous as is also admitted by Koernicke[1] and Kirchner.[2] The details of the process related above vary considerably, however, from those described by the two authors.

The whole process from the time of the opening of the glumes till the anthers assumed the pendent position occupied 10 minutes. Instances were not wanting in which the process took place in as short a time as 3 minutes, while, on the contrary, the process may occupy 30 minutes. Finally as stated above the stamens may never become pendent.

The flowers of the *juar* opened only once, the glumes remaining open for 2—3 hours, the closing of the glumes being a much more gradual process than the opening. The stigmas remained outside after the glumes had closed and appeared quite fresh for as long a period as 24 hours after the glumes had closed. (Fig. 2.) The length of time taken for the whole panicle to complete flowering varied with the size of the inflorescence and the number of flowers. The average time was about seven days.

From the observations it is evident that cross-pollination between flowers of the same panicle is the rule, the pollen from the higher and earlier opening flowers falling on and pollinating the stigmas of lower and later flowers. This is the conclusion also arrived at by Fruwirth[3]. Cross-pollination by foreign pollen can only take place in the first flowers to open, and possibly in the case of late opening flowers whose anthers do not dehisce. Self-pollination can only take place in late opening flowers whose stigmas remain surrounded by the anthers which do not fall out, but even in those cases the chances are in favour of pollination from higher flowers in the same inflorescence. Though typically anemophilous the flowers of the *juar* were visited in considerable numbers by insects. In addition to small beetles which crawled over the panicle, the flowers were regularly visited by bees. During the months of March and April the first bee to arrive soon after day-light was a small bee with white stripes (*Apis florea*). This was followed by the large wild bee

[1] Koernicke, F. *Loc. cit.*

[2] Kirchner, D. *Neue Beobachtungen*, p. 11.

[3] Fruwirth, C. *Die Züchtung der landwirtschaftlichen Kulturpflanzen*, Bd. V, 1912, p. 56.

(*A. dorsata*) and another small bee with yellow stripes (*A. indica ?*). The bees worked carefully over the panicles, picking out the recently opened flowers from whose anthers they milked the pollen with their first pair of legs. By 8 A.M., the visits of the bees had ceased. Undoubtedly the bees are an important agency in bringing about pollination by foreign pollen.

Frequency of Foreign Pollination.

Foreign pollination is much more common in some varieties than in others and observations show that it is less frequent in the compact types of inflorescence and more frequent in the looser types. Amongst the latter foreign pollination is more common in the types with short glumes than in those with long glumes. These observations are in accordance with expectation, the flowers in the compact type of inflorescence being close together and as pointed out above the anthers, in some cases, never falling out of the glumes, while in the flowers with long glumes these furnish a certain amount of protection.

Taking as a basis for comparison the occurrence of foreign pollination in the single plant cultures the following table shows the relative frequency :—

Table III.

	Compact Types			Lax Types with Short Glumes			Lax Types with Long Glumes		
Year	No. of heads sown	No. of crossed flowers	No. of crossed flowers per 100 heads	No. of heads sown	No. of crossed flowers	No. of crossed flowers per 100 heads	No. of heads sown	No. of crossed flowers	No. of crossed flowers per 100 heads
1909	25	3	12	...	...	..	...	...	...
1910	40	6	15	...	...	...	...	...	...
1911	17	4	24	46	24	52	30	8	27
1912	29	6	20	77	223	289	2	3	13
1913	...	...	...	87	198	227	26	9	34
1914	...	..	...	196	413	209	..	...	...
1915	..	...	...	107	126	114	...	...	...

The highest number of crossed flowers was found in Tharthur which showed 165 in 18 lines or 817 crossed flowers per 100 heads.

The percentage of crossing obtained by counting a given number of plants and noting those which were untrue to type is 6% or 97 plants out of 1,577 in a loose type of panicle with short glumes, and only ·6% or 2 plants out of 292

in a compact type of panicle. Tharthur taken in the same way gave 20% or 165 plants out of 828. Ball[1] puts the highest number at 50%.

Examination of Crosses.

Grain characters. The colour of the grain is either red, white, or yellow. The red grains owe their colour to the presence of a red coloured cell sap in the cells of the pericarp. This colouring extends also to other parts of the plant, particularly to the leaves. During the vegetative period the red colour is masked by the chlorophyll, but when the plants ripened the leaves of the red grained plants stand out on account of the red colouring matter contained in the leaves. The yellow colour is similarly due to a yellow coloured cell sap in the cells of the pericarp. The colour likewise extends to the foliage of the plant but at the time of ripening is less noticeable, the darker yellow leaves of the yellow grained plants being liable to be overlooked by a casual observer. The leaves of the white grained plants at harvest are straw coloured. The colour of the plant can be detected at the time of flowering, the stamens and stigmas of the red grained plants being orange, and those of the yellow and white pale yellow.

Cross I.[2]

In the first natural cross observed, namely, Lal Juar, 1908, the head sent in may be taken for our purpose as an F_1 plant, heterozygous with regard to the colour of the grain containing a simple pair of allelomorphs, presence and absence of red. The number of plants was unfortunately small, but the numbers indicated that this cross conformed to the Mendelian interpretation.

Cross II.

In the same year Shenaliwani D proved to be a heterozygous plant for the same pair of characters.

Cross III.

In 1910 Lal Guranj, which had been true to the red character of the grain in the single plant cultures, began to split into red and white. This was evidently a case of natural cross-pollination in the single plant cultures, the hybrid being heterozygous for the same pair of allelomorphs.

1 Ball, C. R. *Loc. cit.*, p. 283.

2 The crosses dealt with in this paper were left unprotected. The reasons for doing so were: first, that the majority of the observations were confined to crosses in the compact type of panicle and the lax type with long glumes in both of which the percentage of natural cross-pollination is extremely low; and second, that the characters under consideration are well marked and the small amount of crossing which occurred was immediately detected.

Cross IV.

Amongst five red grained *juars* from Gunji, secured in the harvest of 1909, three were found to be heterozygous for red and white in the line cultures of 1910, giving numbers closely corresponding to the Mendelian expectation. Further line cultures in 1911 again gave fairly approximate results. The following table sets out the combined figures obtained from these four natural crosses which occurred amongst varieties having a compact type of inflorescence :—

Table IV.

1908	2 plants red			
	Red			White
1909	25			8
Ratio	3·1			1
1909 Plants used as parents	4	21		8
	Red	Red	White	White
1910	All	239	87	All
Ratio		2·7	1	
1910 Plants used as parents	12	25		14
	Red	Red	White	White
1911	All	926	261	All
Ratio		3·5	1	
1911 Plants used as parents	3	11		5
	Red	Red	White	White
1912	All	118	70	All
Ratio		1·7	1	

Cross V.

From 1910-1913 Thaithur, which had been a pure white for the two previous years, produced a small number of red grained plants in the single plant cultures. This was unexpected and the explanation lay in one of two directions:—Either these reds were rogues, *i.e.*, plants from stray seeds, or they were crosses. The small number of red plants might support either supposition. On resowing they proved to be crosses.

Cross VI.

Nilwa in 1910 produced in the line culture seven red grained plants, the rest of the line being white grained. On resowing, these red grained plants proved to be crosses splitting into red and white. Nilwa appears to be a variety very liable to cross-pollination, the percentage of crosses being as high as 6%.

The following table sets out the combined figures obtained from the last two natural crosses which occurred in varieties having a loose type of panicle with short glumes:—

TABLE V.

1910	7 plants red			
	Red			White
1911	331			146
Ratio	2·2			1
1911 Plants used as parents	2	30		3
	Red	Red	White	White
1912	All	647	309	All
Ratio		2·1	1	
1912 Plants used as parents	5	25		9
	Red	Red	White	White
1913	All	846	475	All
Ratio		1·8	1	

Cross VII.

Four of the red grained plants from Gunji in 1910 were found to be heterozygous for red and yellow in the line cultures of 1911. The numbers correspond with those expected under Mendel's law. Further line cultures in 1912 gave again an almost mathematical demonstration of Mendel's law.

Table VI.

Gunji Red.

1911	4 plants red			
	Red			Yellow
1912	94			32
Ratio	2·9			1
1912 Plants used as parents	3	10		7
	Red	Red	Yellow	Yellow
1913	All	300	102	All
Ratio		2·9	1	

Cross VIII.

One of two yellow grained *juars* from Gunji secured in the harvest of 1909 was found to be heterozygous for yellow and white grain in the cultures of 1910. On further culture the same phenomenon was observed. The number indicated segregation as described by Mendel.

TABLE VII.

Gunji Yellow.

1909	1 plant yellow			
	Yellow			White
1910	12			4
Ratio	3			1
1910 Plants used as parents.	4	5		4
	Yellow	Yellow	White	White
1911	All	135	27	All
Ratio		5	1	

Thirty yellow grained plants of Gunji from the harvest of 1912 were grown and the result in 1913 was in accordance with the above observation. In seven cases evidence of further natural crossing was apparent but this does not vitiate the result appreciably.

TABLE VIII.

Gunji Yellow.

1912 ..	30 plants yellow					
	17	6		7		
1912 Plants used as parents	Yellow	Yellow	White	Yellow	White	Red
1913 ..	All	114	28	165	51	10
Ratio ...		4	1	3·2	1	

Cross IX.

The next cross Gunji resulted in the production of three types of plants distinguished as Red grained, Yellow grained, and White grained, respectively. Taking the families in which all three colours occur we find the total Red, 340, Yellow, 96, and White, 139. This approximates to a 9 : 3 : 4 ratio fairly closely, the expectation on that supposition being Red, 325; Yellow, 105; White, 140. The red grained plants proved in further cultures to be of three types, the yellow of two and the white of one type. On crossing a number of the whites with one of the pure yellows, however, the whites proved to be of at least two kinds, namely, those which gave a red grained F_1 plant and those which gave a yellow grained F_1 plant.* This leads to the assumption that some of the whites are really undeveloped reds and only require the addition of yellow to cause the red colour to develop. The complementary factors that compose the red colour are separate, one being contained in the white grained plant and the other in the yellow grained. When both of these combine the red colour is produced. The simplest solution suggested by Mr. H. Martin Leake to whom I desire to tender my thanks for the suggestion is one involving only two factors R (red) and Y (yellow). The simplest case of such a combination is one in which RrYy will give 12 Red, 3 Yellow, 1 White, supposing red completely masks yellow. If we suppose that Red can only develop in the presence of yellow then RrYy gives 9 Red, 3 Yellow, 4 White.

The actual numbers are given in the table on page 212.

* *Artificial cross-pollination.* Juar presents few difficulties with regard to artificial cross-pollination. The inflorescence can be mutilated very considerably without apparently interfering with the fruit development of the remaining flowers. The fruits also develop freely inside protecting envelopes. The method employed was to select a plant in which the panicle was just emerging from the leaf sheath. In the afternoon all the topmost branches, with the exception of three, were removed; at the same time the lower branches were removed to expose the rachis which forms a useful support on which to fasten the protecting envelope. The removal of the lower branches further prevented the chance of pollen from the lower flowers adhering to the mouth of the envelope during subsequent examination of the protected flowers. All the flowers were removed from the three top-most branches except one near the tip of each branch and one near the lower end of the branch. The glumes were thereafter gently forced apart by holding the awn with forceps and pressing the glumes laterally. The flower was thus easily castrated and was then protected in the usual way by an envelope. When the stigmas were mature—this being ascertained by removing the envelope, when, if the stigmas are mature, the glumes are found to be open with the stigmas extruding—pollen was applied. It is necessary to make the examination early in the morning, though castrated flowers in envelopes remain open for a longer time than exposed flowers. After the grain had set the bottom of the envelope was torn off, the remaining portion serving the double purpose of a distinguishing mark and a protection from birds. Control flowers showed that there was little danger of accidental self-pollination during the process of castration if ordinary precautions were taken.

TABLE IX.

Gunji Red.

1908	1 plant red		
	Red	Yellow.	White
1909	5(*a*)	2(*b*)	4
Expectation	9	6	4

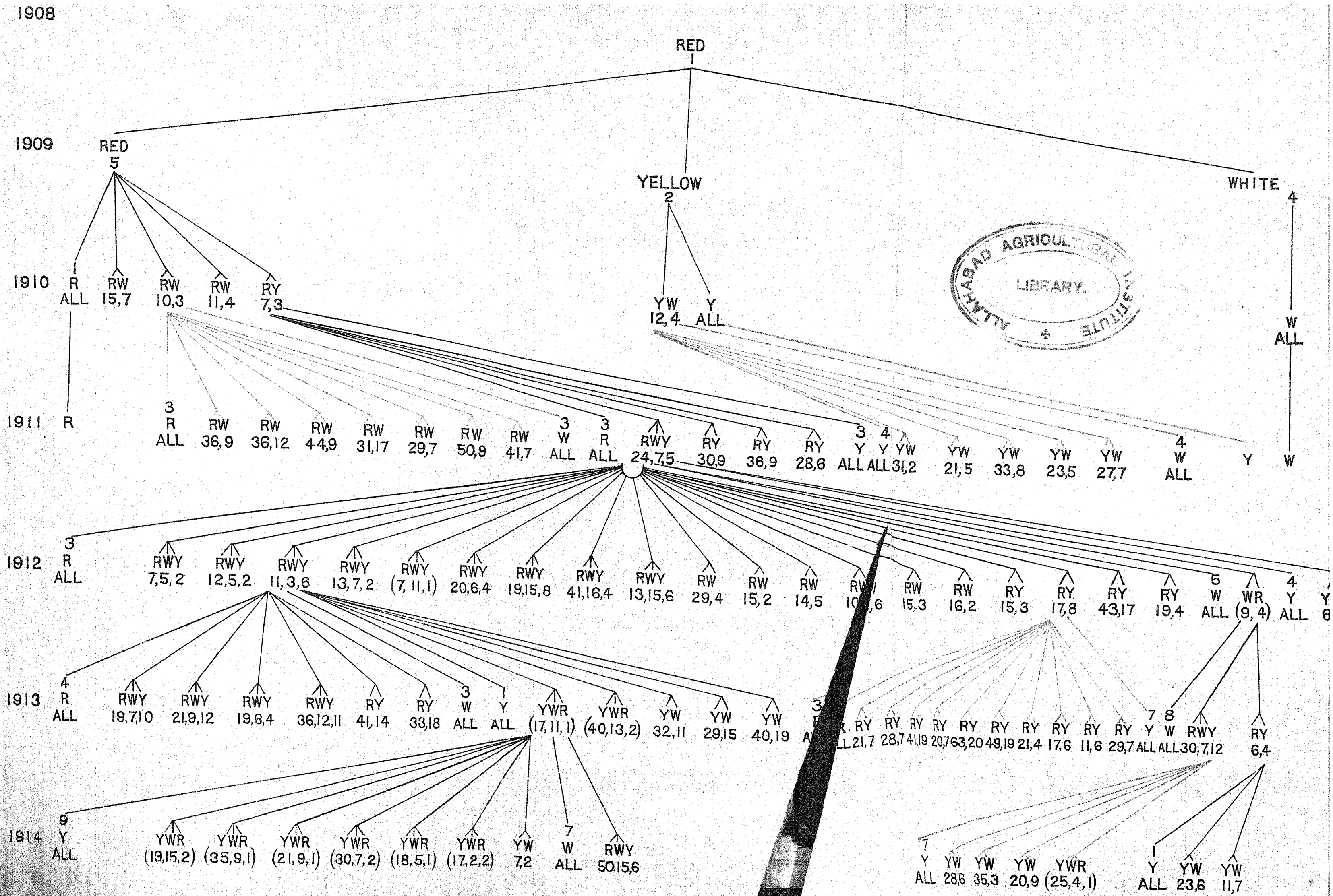
1909 Plants used as parents ...	RRYY 1(*a*)	RrYY 1(*a*)		RRyy 3(*a*)		rrYY 1(*b*)	rrYy 1(*b*)		
	Red	Red	Yellow	Red	White	Yellow	Yellow	White	
1910	All	7(*c*)	3(*d*)	36	14	All	12	4	
Expectation	All	9	3	42	14	All	12	4	

1910 Plants used as parents...	3(*c*)	3(*c*)		RrYy 1(*e*)			3(*d*)
	Red	Red	Yellow	Red	Yellow	White	Yellow
1911	All	94	24	24(*e*)	5(*f*)	7(*g*)	All
Expectation	All	72	24	24	8	9	All

1911 Plants used as parents...	3(*e*)	6(*e*)		4(*e*)		9(*e*)			4(*f*)	1(*f*)		6(*g*)	1(*g*)	
	Red	Red	White	Red	Yellow	Red (*f*)	Yellow (*g*)	White (*h*)	Yellow	Yellow	White	White	White	Red
1912	All	99	22	94	32	136(*h*)	34(*i*)	72(*j*)	All	6	2	All	9	4
Expectation	All	66	22	96	32	135	45	60	All	6	2	All		None

1912 Plants used as parents...	4(*h*)	2(*h*)		4(*h*)			1(*i*)	3(*i*)		2(*i*)			3(*j*)
	Red	Red	Yellow	Red	Yellow	White	Yellow	Yellow	White	Yellow	White	Red	White
1913	All	74	32	125	49	41	All	101	45	57	24	3	All
Expectation	All	96	32	125	42	56	All	135	45	72	24	None	All

Parentage of plants is indicated by letters (*a*)—(*j*).


1908
RED 1
1909
RED 5
YELLOW 2
WHITE 4
1910
1 R ALL
RW 15,7
RW 10,3
RW 11,4
RY 7,3
YW 12,4
Y ALL
W ALL
1911
R
3 R ALL
RW 36,9
RW 36,12
RW 44,9
RW 31,17
RW 29,7
RW 50,9
RW 41,7
3 W ALL
3 R ALL
RWY 24,7,5
RY 30,9
RY 36,9
RY 28,6
3 Y ALL
4 Y ALL
YW 31,2
YW 21,5
YW 33,8
YW 23,5
YW 27,7
4 W ALL
Y
W
1912
3 R ALL
RWY 7,5,2
RWY 12,5,2
RWY 11,3,6
RWY 13,7,2
RWY (7,11,1)
RWY 20,6,4
RWY 19,15,8
RWY 41,16,4
RWY 13,15,6
RW 29,4
RW 15,2
RW 14,5
RW 15,3
RW 16,2
RY 15,3
RY 17,8
RY 43,17
RY 19,4
6 W ALL
WR (9,4)
4 Y ALL
1913
4 R ALL
RWY 19,7,10
RWY 21,9,12
RWY 19,6,4
RWY 36,12,11
RY 41,14
RY 33,18
3 W ALL
1 Y ALL
YWR (17,11,1)
YWR (40,13,2)
YW 32,11
YW 29,15
YW 40,19
RY 21,7
RY 28,7
RY 41,19
RY 20,7
RY 63,20
RY 49,19
RY 21,4
RY 17,6
RY 11,6
RY 29,7
7 Y ALL
8 W ALL
RWY 30,7,12
RY 6,4
1914
9 Y ALL
YWR (19,15,2)
YWR (35,9,1)
YWR (21,9,1)
YWR (30,7,2)
YWR (18,5,1)
YWR (17,2,2)
YW 7,2
7 W ALL
RWY 50,15,6
7 Y ALL
YW 28,6
YW 35,3
YW 20,9
YWR (25,4,1)
1 Y ALL
YW 23,6
YW 11,7

The accompanying diagram shows the relationships between the line cultures of each year. It will be noticed that there are numerous natural crosses. These numbers have been enclosed in brackets. The figures below each letter give the number of plants of the colour occurring in the line.

Glume characters. The varieties of *juar* can be divided into two main groups as regards the length of the glumes in comparison with the size of the grain. The commoner type has the glumes shorter than the grain which is thus exposed and appears to be held in a cup formed by the glumes; the less common type has the glumes much longer than the grain. The glumes meet above and conceal the grain. The long glume character is, so far as observation goes, always associated with a loose type of panicle.

Cross X.

The first cross between the long glumed *juar* and the short was noticed in 1911 when in a pure line of Galgalya six short glumed heads were observed. These on further culture split into long and short in a ratio which corresponds very closely with the Mendelian ratio, 3 : 1.

Table X.

Galgalya (long glume).

1911	6 plants short			
	Short			Long
1912	60			20
Ratio	3			1
1912 Plants used as parents ...	4	7		3
	Short	Short	Long	Long
1913	All	192	61	All
Ratio		3·1	1	

The accompanying diagram shows the relationships between the line cultures of each year. It will be noticed that there are numerous natural crosses. These numbers have been enclosed in brackets. The figures below each letter give the number of plants of the colour occurring in the line.

Glume characters. The varieties of *juar* can be divided into two main groups as regards the length of the glumes in comparison with the size of the grain. The commoner type has the glumes shorter than the grain which is thus exposed and appears to be held in a cup formed by the glumes; the less common type has the glumes much longer than the grain. The glumes meet above and conceal the grain. The long glume character is, so far as observation goes, always associated with a loose type of panicle.

Cross X.

The first cross between the long glumed *juar* and the short was noticed in 1911 when in a pure line of Galgalya six short glumed heads were observed. These on further culture split into long and short in a ratio which corresponds very closely with the Mendelian ratio, 3 : 1.

Table X.

Galgalya (long glume).

<table>
<tr><td>1911 ... ...</td><td colspan="4">6 plants short</td></tr>
<tr><td></td><td colspan="3">Short</td><td>Long</td></tr>
<tr><td>1912 ... ...</td><td colspan="3">60</td><td>20</td></tr>
<tr><td>Ratio ... ...</td><td colspan="3">3</td><td>1</td></tr>
<tr><td>1912 Plants used as parents ...</td><td>4</td><td colspan="2">7</td><td>3</td></tr>
<tr><td></td><td>Short</td><td>Short</td><td>Long</td><td>Long</td></tr>
<tr><td>1913 ... ...</td><td>All</td><td>192</td><td>61</td><td>All</td></tr>
<tr><td>Ratio ... ...</td><td></td><td>3·1</td><td>1</td><td></td></tr>
</table>

Cross XI.

In 1911 amongst the white grained plants of Cross No. V, two lines were found containing plants with long and short glumes respectively, the proportion of which was very nearly 3 short : 1 long. It was therefore obvious that the parent heads from which those lines were sown were heterozygous for the long and short glume characters respectively.

Table XI.

Nilwa (short glume).

1910	2 plants short						
	Short				Long		
1911	32				18		
Ratio	1·7				1		
1911 Plants used as parents	14	17			16	2	
	Short	Short		Long	Long	Short	Long
1912	All	271		87	All	42	6
Ratio		3·1		1			
1912 Plants used as parents	16	65		9			
	Short	Short	Long	Long			
1913	All	1236	422	All			
Ratio		2·9	1				

Cross XII.

In 1911 a short red *juar* was observed in the pure line of white Galgalya. This on resowing split into four types of heads—red short, red long, white short, and white long. The original short red was therefore heterozygous for two pairs of allellomorphs, *viz.*, red and white in the colour of the grain, and shortness and longness in the length of the glume.

TABLE XII.

Galgalya (red short glume).

<table>
<tr><td>1911 ... ...</td><td colspan="25">1 plant red short</td></tr>
<tr><td></td><td colspan="20">Red Short</td><td>Red Long</td><td colspan="3">White Short</td><td>White Long</td></tr>
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<tr><td>Expectation ... ...</td><td colspan="20">9</td><td>3</td><td colspan="3">3</td><td>1</td></tr>
<tr><td>1912 Plants used as parents...</td><td colspan="16">3</td><td colspan="2">3</td><td colspan="2">2</td><td>3</td><td colspan="2">3</td><td>1</td><td>1</td></tr>
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<tr><td>Expectation .. ...</td><td>All</td><td>81</td><td>27</td><td>27</td><td>9</td><td>117</td><td>39</td><td>120</td><td>40</td><td>All</td><td>180</td><td>60</td><td>All</td><td>156</td><td>52</td><td>All</td><td colspan="9"></td></tr>
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SUMMARY.

Andropogon Sorghum, Brot. is protogynous. Normally the flowers are pollinated from the higher flowers of the same panicle. The flowers though typically anemophilous are regularly visited at certain seasons by insects, chiefly bees. This undoubtedly leads to natural cross-pollination, the liability to which depends on the structure of the panicle, being greater in the laxer forms.

Flowering takes place in a fairly regular order. During the months over which the observations extended, the majority of the flowers opened between 2 and 4 A.M. Stray flowers may open before or after, this being influenced by the moisture conditions of the air.

In the grain the red colour and the yellow colour behave as simple allellomorphs, as also do the red colour and the white colour, red being in both cases dominant. Likewise the yellow colour and the white colour may behave as simple allellomorphs, or the heterozygote may be red, behaving as a dihybrid with a 9 : 3 : 4 ratio for red, yellow and white, respectively. The simplest explanation is that certain white grained plants are undeveloped reds requiring the presence of yellow to cause the red colour to develop.

In the glumes the long character and the short character behave as simple allellomorphs.

NAGPUR,

October 1915.

PHYTOPHTHORA SP. ON *HEVEA BRASILIENSIS.*

BY

JEHANGIR FARDUNJI DASTUR, B.Sc.,

First Assistant to the Imperial Mycologist.

INTRODUCTION.

A POPULAR account of the disease of *Hevea* stem and fruit known in Burma as "Black Thread" and caused by a *Phytophthora* has been published by the Burma Department of Agriculture.[1] It is therefore not necessary in this paper to discuss the macroscopic characters of this disease.

The "Black Thread" disease first attracted the attention of the Burma Rubber Planters five or six years ago when the disease became very prominent by the damage it did on the tapping area. However it seems to be of a longer standing in Burma, at least on the fruits. As far back as 1905 specimens of diseased *Hevea* fruits from Mergui were sent to the Imperial Mycologist for examination, and in 1906 the Manager of the Rubber Plantation, Mergui, wrote that it was the fourth year the fruits in the garden had been attacked but that in no case had the disease been noticed on any other part of the tree except the fruit. They were at that time supposed to be attacked by a *Nectria;* but specimens of these diseased fruits sent in 1905 from Mergui have been examined by me and they show not only the presence of *Nectria* but also the resting conidia of a *Phytophthora* similar to those found by me in Burma in 1915. It is therefore reasonable to conclude that the disease of the fruits caused by a *Phytophthora* has been present in Burma at least since 1903; whether the disease on the tapping area is as old as this it is difficult to say.

MICROSCOPIC CHARACTERS.

Sections through diseased tapping areas show the cell walls turned brown or yellow and in some cases swollen and the cell contents destroyed. At times the stratification of the swollen cell wall appears very distinctly. The

[1] Dastur, J. F. Black Thread Disease of *Hevea* in Burma. Dept. Agr., Burma, Bull. No. 14, 1916.

cell cavity is sometimes filled with a yellow or brown gummy substance. On account of the death of the protoplasm and the loss of the water contents of the cell the cell walls collapse. The depression of the diseased area may be due to this collapse of the cell walls of the outer tissues. It is between these swollen and diseased cell walls that unseptate hyphæ are to be found.

It is difficult to trace the hyphæ, as they are generally completely masked by the presence of the brown pigment, which also prevents the affected cell walls from being stained by staining reagents. The presence of the hyphæ can be detected when the sections are treated with dilute ammonia or when they are subjected to ammonia vapour for a minute; chloral hydrate also tends to clear the pigment and thereby to reveal the presence of the fungus; boiling the sections for a few seconds in hydrochloric acid, as recommended by Ducomet,[1] either completely removes the pigment or leaves in the tissues only a slightly yellow tinge, if then washed in water and boiled with lactic acid, the hyphæ can be seen and will stain faintly blue with cotton blue. The hyphæ in the stem have been found to be intercellular and confined to the soft tissues. They are not to be found between the walls of the sclerotic cells though the latter are often filled with the brown gummy substance; they are also absent from between the walls of the wood cells. Haustoria are of rare occurrence and have been chiefly observed in the cortex; they are globose or finger-shaped (Fig. 1). In the tissues of the rind of the diseased fruits the mycelium is both inter-and intra-cellular. The hyphæ are confined to the tissues of the rind. They have not been found to penetrate the tissues of the woody shell, but in advanced cases of attack they reach the inside of the shell through the sutures. Bacteria and fungi like *Botryodiplodia*, *Fusarium*, *Nectria*, *Glœosporium* and others coming in the wake of *Phytophthora* then completely destroy the fruit.

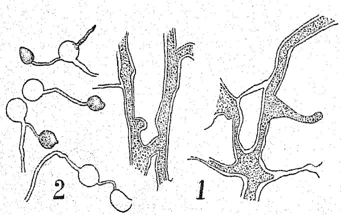

Fig. 1. Intercellular mycelium with haustoria from diseased tissues of the stem. ×365.
Fig. 2. Germination of the zoospores. ×480.

[1] Ducomet, V. Recherches sur le développement de quelques champignons parasites à thalle subcuticulaire, p. 11, 1907.

The hyphæ in the epidermal cells of the fruit form a stroma-like body which completely destroys the host cells (Figs. 1—3). When young this is composed of a single layer of pallisade cells with one or two rows of small basal cells. These cells enlarge and press against the cuticle pushing it out and ultimately rupturing it. The apical cells grow considerably in size, generally more breadthwise than lengthwise, thus losing their pallisade shape (Figs. 4 and 8); at the same time they also become sometimes lobed (Fig. 7). This stromatoid body has always been found to consist of loose cells. This is very clearly seen in tangential sections (Fig. 3). All the cells remain hyaline and are filled with finely granular protoplasm. From the top of the apical cells arise sporangiophores, usually one from each cell but, at times, as many as three (Figs. 2 and 4—8). The tissues of the fruit in the neighbourhood of the stroma-like body become discoloured and the cells are filled with some brown substance.

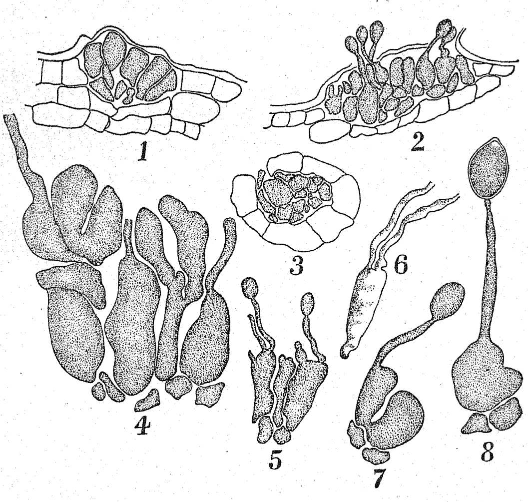

Fig. 1. A young stromatoid structure as seen in a transverse section of the diseased fruit. ×480.
Fig. 2. A mature structure bearing sporangia. ×215.
Fig. 3. A tangential section showing the loose cells forming the stroma-like body. ×480.
Figs. 4-8 Cells of the stromatoid body. ×480.

This formation of such a stroma-like body has not been, as yet, observed in any of the *Phytophthoras* known. The only other genus of the *Peronosporaceæ* in which something akin to it is formed is *Cystopus* and even here the base of the sorus consists merely of the swollen pedicels of the spore-chains and no formation of distinct basal cells interposed between the mycelium and the spore stalks occurs. De Bary considers that some characters found in *Pythium* suggest a common ancestry for *Cystopus* and *Phytophthora* and therefore the finding of this sorus-like structure in a *Phytophthora* is of interest as recalling the sori of the *Cystopus.* In *Cystopus,* however, the hyphæ beneath the epidermis bear directly a tuft of broad basidia from each of which a single chain of sporangia arises while in the *Phytophthora* under study the basidium or apical cell of the stromatoid body bears not alone one but as many as three sporangiophores.

The sporangiophores vary much in length ; at times they are extremely small, the sporangia being almost sessile on the epidermis. Sometimes the spore stalk instead of bearing a sporangium directly after it has emerged from the epidermis continues its vegetative growth, and sends out branches which ultimately bear sporangia. The sporangiophores are simple ; only occasionally branched. Sporangia are ovate or citron-shaped and terminal ; at times lateral. The number of zoospores in a sporangium varies with the size of the sporangium. They are bean-shaped with a pointed anterior and have two cilia of unequal size. After swimming for some time the zoospores come to rest, lose their cilia, round off and germinate by sending out one to three germ-tubes which either continue their vegetative growth or when quite small swell at the tips to form secondary sporangia which when mature liberate one to three zoospores (Fig. 2, p. 218). Resting conidia are borne in the felt of mycelium on the surface of the fruit and on the tapping cut. They are honey-coloured, yellowish or at times hyaline, generally round, and they are either terminal, lateral, or intercalar.

INOCULATIONS ON *HEVEA*.

In order to verify that this *Phytophthora* was the cause of the "Black Thread" disease, inoculation experiments with pure cultures obtained from diseased fruits have been carried out. The inoculations were at first done by putting a bit of the mycelium on a newly tapped surface ; the inoculated areas were kept covered from 24 to 48 hours with cotton soaked in sterilized water. In four days the points inoculated showed signs of successful infection : they had turned either black or had vertical black lines, and had become slightly depressed. Within a week they showed typical symptoms of "Black

Thread." Vertical cracks were present on the inoculated areas and in some cases there was even an exudation of latex in drops. Sections from these areas showed the presence of intercellular hyphæ in the tissues, which had turned brown as in the case of naturally diseased tissues. Of the 55 inoculations made only 4 were unsuccessful.

Inoculations in a similar way were also made on renewing bark and old bark. Fifteen inoculations on the uninjured renewing bark where the cork formation had taken place and 18 inoculations on the uninjured old bark were made; all these failed. When, however, the bark was removed thereby exposing the outer green tissues of the cortex, the inoculations were successful. Of the 33 made only one failed. The inoculated tissues turned black, became depressed and developed vertical cracks. The blackening of the tissues did not extend beyond the cut and practically remained confined to the exposed green cortex, at least for three weeks, and had not during this period reached the cambium; only when the bark round the inoculated area was removed, laying bare healthy green tissues, did the infection spread outwards and attack the newly opened tissues. On branches also inoculations failed on the uninjured bark (7 inoculations were made) but succeeded on newly opened green tissues (18 inoculations were made). In those cases in which the tissues were wounded almost as far as the cambium, which was itself uninjured, gaping wounds exposing the wood were formed as the result of the inoculation. All these experiments were carried out on mature trees, *i.e.*, trees more than 6 to 7 years old. Trees 1 to 5 years old have also been experimented upon and the results have been the same. Six inoculations made on the uninjured thin epidermis have been unsuccessful, but on 19 young trees where the epidermis was injured the inoculations succeeded; the same results have been produced with saplings a few months old; in all these cases inoculations were made in the same way as described in the first case. In a few cases zoospores were used instead of the mycelium and inoculations on freshly opened tissues have been equally successful. Some of the successful inoculations have also produced sporangia.

Morphology of the Fungus in Culture Media.

This fungus has been grown in various culture media to induce it to produce oospores; but all attempts have failed.

In some agar media sporangia are much bigger than those found on the host plant. In nutrient media they vary from 25 to 51μ in length and 19 to 37μ in breadth; they are terminal, lateral or even intercalar. The number of zoospores liberated by some of these sporangia is as much as 30; the size of

the zoospores produced in culture media is almost the same as those produced on the host plant. The resting conidia in nutrient media do not show as much variation as the sporangia. They are only slightly bigger than those found in nature.

In water cultures the branching of sporangiophores is as complex as those of *Ph. omnivora*; sporangia are of the same size as those found on the host plant.

The fungus grows luxuriantly in French bean juice agar, Quacker oat agar, Oat juice agar, Gram agar, and Green peas agar. In these media the aerial growth is very profuse, the culture tubes being completely filled by it within a week.

In glucose meat-extract agar the mycelium remains submerged and forms on the surface a thick undulating mat. The hyphæ are richly branched, irregularly swollen and full of highly granular protoplasm and oil globules. Sporangia and resting conidia are fairly numerous.

If this culture medium contains a trace of potassium phosphate the fungus remains sterile. Instead of this salt if one per cent. tannic acid be added the growth is similar but sporangia and resting conidia are produced in abundance. The colour of the resting conidia varies from deep honey to light yellow.

Klebs[1] and Kauffman[2] have found hæmoglobin to be one of the best substances for the formation of sexual organs in *Saprolegniaceæ*. In solutions of 0·1 per cent. and of 0·05 per cent. hæmoglobin and of 0·1 per cent. hæmoglobin with 0·1 per cent. of peptone and of 0·05 hæmoglobin with 0·02 per cent. peptone the *Phytophthora* under study did not produce these organs. The growth was rather poor. The mycelium remained settled at the bottom of the solution like a woolly ball. The mycelium was branched; sporangia and resting conidia were fairly abundant.

As in liquid solutions the growth of the fungus is rather poor, 0·1 per cent. hæmoglobin was added at about 50°C. to sterilized French bean juice agar and Oat juice agar. The growth of the fungus was good. Sporangia and resting conidia were produced in large numbers. Resting conidia formed near a granule of hæmoglobin were generally deeply coloured, dark brown or deep honey-coloured; no sexual spores were produced. Traces of potassium phosphate and calcium nitrate were added to French bean juice agar with

[1] Klebs, G. Zur Physiologie der Fortpflanzung einiger Pilze II *Saprolegnia mixta*. Jahrb. Wiss. Bot. xxxiii, 1899.

[2] Kauffman, C. H. A contribution to the Physiology of the *Saprolegniaceæ*, with special reference to the variations of sexual organs. Ann. Bot. xxii, 1908, p. 362.

hæmoglobin. The growth of the fungus was inclined to be confined to the surface of the medium. Hardly any sporangia were formed but resting conidia were produced in large numbers.

To glucose meat-extract agar were added traces of hæmoglobin, potassium phosphate, and calcium nitrate. The growth of the fungus in this medium was similar to that in glucose meat-extract agar. Hardly any sporangia and a few resting conidia were produced.

In horse dung agar the growth was very scanty and entirely submerged. Sporangia were produced in large numbers but resting conidia very few. In horse dung solution the growth was very poor. Sporangia were fairly many but resting conidia very few.

On sterilized potato cylinders the aerial growth is very little ; at first the mycelium remains closely appressed to the surface of the cylinder. Resting conidia are produced in large numbers but sporangia very few.

On sterilized pods of green peas the fungus grows very well. There is a good aerial growth. Resting conidia are developed in large numbers; sporangia very few.

On sterilized ants the fungus did not grow.

In culture media this fungus does not produce the stroma-like bodies which it forms on fruits.

Comparison between the *Phytophthora* disease of *Hevea* in Burma and in other *Hevea*-growing countries.

In Ceylon *Hevea* canker was investigated in 1903 by Carruthers[1] and was supposed to be caused by a *Nectria*. Petch[2] in 1910 inoculated ten *Hevea* stems with *Phytophthora* spores obtained from diseased cacao fruits and three more by inserting in wounds pieces of diseased cacao pods. Six out of these thirteen inoculations gave definite infections and therefore he concluded that canker and pod disease of *Hevea* are caused by the same *Phytophthora* which is responsible for the stem canker and pod rot of cacao, *viz.*, *Ph. Faberi* Maub.

According to Petch[3] who has studied *Hevea* canker in Ceylon under field conditions in great detail, *Ph. Faberi*, the accepted cause of canker,

[1] Carruthers, J. B. Canker (*Nectria*) of Para Rubber (*Hevea Brasiliensis*). Circs. & Agr. Jour. Roy. Bot. Gard., Ceylon, II, No. 29, 1905, p. 445.

[2] Petch, T. Cacao and *Hevea* Canker. Circs. & Agr. Jour. Roy. Bot. Gard., Ceylon, V, No. 13, 1910, p. 159.

[3] Petch, T. The Physiology and Disease of *Hevea Brasiliensis*, 1911, pp. 199—201.

does not cause a true canker on *Hevea;* the diseased bark is usually smooth and outwardly appears to be sound; the fungus forms no open wounds and therefore he considers the popular name canker to be a misnomer. Again a cankered tree may be killed and the bark destroyed "without the occurrence of any roughness or open wounds." "Black Thread" causes a true canker; the diseased renewing bark in advanced cases completely decays and falls off leaving a big gaping wound and in the case of a minor attack the renewal of the bark is rough with vertical swollen ridges of wound tissue. However serious be the attack of "Black Thread," it has not been known to kill the tree. *Hevea* canker is found even when the stem has acquired a thick outer brown bark while "Black Thread" is confined on the stem solely to the tapping surface. In the case of *Hevea* canker, therefore, there is generally no outward indication of the disease while the presence of the Burma disease can always be spotted immediately on its appearance. In some cases, however, the cankered bark exudes a reddish or purplish liquid, which gives an outward symptom of the diseased condition of the bark: in the Burma disease no such discoloured exudation has been observed, but there is an exudation of white latex from the vertical cracks on the diseased parts. From Petch's accounts *Hevea* canker does not appear to be a wound parasite on the stem, but "Black Thread" is, as is shown by inoculation experiments and by the characters of this disease in nature.

During the prolonged rains of 1909 and 1910 Petch[1] found in Ceylon the decay of the renewing bark on the tapped surfaces. The decay was first indicated by the appearance of vertical black lines, just above the tapping cut. This decay was found to extend to the wood; the bark on the diseased area rotted and left long narrow wounds extending to the wood. The progress of the decay stopped when the rains ceased and the wounds healed up but the renewal of the bark was rough with vertical swollen ridges of wound tissue. This description by Petch of the disease of the tapping surface in Ceylon very much resembles that of "Black Thread" of Burma; but there is one point of minor difference; according to Petch in some cases the decay travelled downwards and involved the untapped bark; Rutgers[2] also has found in Java that the disease penetrates downward in the old bark; in Burma, however, "Black Thread" has never been observed to involve the untapped bark. Petch considers the decay of the renewing bark on the tapped surface due

[1] Petch, T. Cacao and *Hevea* Canker. Circs. & Agr. Jour. Roy. Bot. Gard., Ceylon, V, No. 13, 1910, p. 166.

[2] Rutgers, A. A. L. and Arens, P. Diseases of *Hevea Brasiliensis* in Java. Internationaal Rubber-Congres met Tentoonstelling, Batavia, 1914, p. 5.

to an excess of moisture on the layer exposed to the rain during tapping and not due to any pathogenic cause, because he failed to reproduce this decay by means of organisms found in the decayed bark. He does not enumerate them but presumably he did not find a *Phytophthora* among them. The writer found in Burma that the decaying bark was soon overrun by saprophytic fungi like *Fusarium*, *Cephalosporium* and *Spicaria*, especially the first. To see if any of them was able to cause " Black Thread " tapped areas were inoculated with pure cultures of these fungi but in all cases negative results were obtained. The sporangia of *Phytophthora* are very rarely formed on the diseased stem in Burma, and the writer succeeded in getting the sporangia from the incubated decayed bark only in a few cases after many attempts and that, too, when a thick piece from the diseased part of the stem was incubated after washing the piece in corrosive sublimate. Even then a pure growth of the fungus was not obtained as there was also a Fusarial growth.

Petch's[1] account of *Hevea* pods attacked by *Phytophthora* in Ceylon may well apply to the diseased pods in Burma, but in Ceylon the fungus from the fruit may grow through the stalk into the branch and kill it for some distance, while in Burma the disease from the fruit has not been found to travel on to the stalk and thence to the branch, though diseased fruits have been found hanging on the trees for several weeks. In the case of a fruit badly attacked by *Phytophthora* in Burma, the woody shell underneath the diseased soft rind shows black discoloured areas. On sectioning these, *Botryodiplodia* hyphæ have been found in the tissues. This fungus from the woody shell has been found to travel on to the thalamus; and from there it may reach the fruit stalk and eventually kill it. Petch[2] has shown that *Botryodiplodia Theobromeœ* Pat. may follow an attack of *Glœosporium* on *Hevea* branches; similarly it is possible that on the fruit in Burma *Botryodiplodia* follows an attack of *Phytophthora* and then spreads to the fruit stalk. It seems probable, therefore, that in Ceylon also the death of the fruit stalk may be due to *Botryodiplodia* and not due to *Phytophthora* as supposed by Petch, especially since he says that *Phytophthora* has not been isolated from diseased fruit-bearing shoots.

In Ceylon *Ph. Faberi* has been found to attack the collar and the roots as well, in fact all parts of the tree, except leaves. But McRae and Sundararaman,[3], who have studied in Travancore and Cochin a disease of *Hevea* which they consider to be due to *Ph. Faberi*, have found the presence of this fungus

[1] Petch, T. *loc. cit.*

[2] Petch, T. Physiology and Diseases of *Hevea Brasiliensis*, 1911, p. 220.

[3] McRae, W. and Sundararaman, S. Leaf-fall of *Hevea*. The Planters' Chronicle, X, No. 37, 1915, p. 452.

not only on fruits and the tapping area of the stem but also on young tender leaflets, leaves in the buds, stalk of leaflets, main stalk of the leaf and on young branches. In Burma the parasite has been found to attack only fruits and the tapping surface. McRae and Sundararaman report that a second leaf-fall occurs in Travancore and Cochin in July and August, and they are of opinion that though their experiments do not prove that *Ph. Faberi* is the cause of the second leaf-fall, the presence of this fungus on the leaves is suggestive. According to Petch[1] the fungus from the fruits passes on to the green shoots and kills them back or it attacks the stalks and causes extensive defoliation and in a recent Report[2] of the Department of Agriculture, Ceylon, he says that the leaf-fall which often follows the fruit disease and is characterized by the appearance of a dark brown ring on the leaf stalk is caused by *Ph. Faberi.* A similar leaf-fall also occurs at Twante in Burma but the writer could not trace the fall to any pathogenic fungus. The falling leaf stalks were found to be healthy as far as any parasitic organism was concerned and the leaf stalk did not show any dark brown ring. The falling leaves did not become curled or flaccid. The writer was inclined to attribute the fall to the excessive humidity prevalent in July.

In Cochin and Travancore the *Phytophthora* which attacks fruits of *Hevea* producing symptoms similar to those found on diseased fruits in Burma also causes the darkening of the renewing bark a little above the tapping cut ; it seems, therefore, that in all probability this *Phytophthora*, which McRae[3] does not now consider to be the same as *Ph. Faberi*, is identical with the one causing " Black Thread " in Burma, in spite of the differences enumerated above. The tendency of the South India *Phytophthora* to attack various parts of *Hevea* is probably to be attributed to local climatic conditions.

Rutgers[4] distinguishes two acute forms of *Hevea* canker in Java, Sumatra and Borneo which he considers to be due to the same fungus *Ph. Faberi*. One form is form A or "Streepjeskanker " and the other is form B or " Vlekkanker." His illustration and description of the former, " Streepjeskanker," clearly show

[1] Petch, T. The Fungus-diseases of *Hevea brasiliensis*. Internationaal Rubber-Congres met Tentoonstelling, Batavia, 1914, p. 12.

[2] Petch, T. Rep. Dept. Agr. Ceylon, July 1912 to Dec. 1913. Pub. in 1914, p. c7.

[3] McRae, W. Administration Report of the Government Mycologist for 1915-1916, Rep. Dept. Agr., Madras, 1915-1916, Pub. 1916, p. 53.

[4] Rutgers, A. A. L. and Dammerman, K. W. Ziekten en Beschadigingen van *Hevea Brasiliensis* op Java. Dep. Landbouw Nijverheid en Handel. Meded.Labor. voor Plantenzeikten. No. 10, 1914, pp. 27—30, and

Rutgers, A. A. L. and Arens, P. *loc. cit.* 1914, pp. 27—30.

that it is identical with the " Black Thread " disease of *Hevea* in Burma. The form B, " Vlekkanker " includes the well-known greyish-brown or purplish-red or red patches in the bark first described in the canker formed on cacao and subsequently in the rubber canker described by Petch in Ceylon. Besides the red canker patches of form B, the innermost layers of the bark quite near the cambium, or the cambium itself, show a slight discolouration, which appears on the tapping cuts in the form of dirty brown or greyish points and lines or as a dirty brown line in the place of the cambium. This form C gives rise to burrs if not treated in time. It is not clear why Rutgers considers the two acute forms, A and B noted above to be due to the same fungus *Ph. Faberi.* He inoculated cacao *Phytophthora* on *Hevea* and got the typical canker, form B, in every case ; but when he inoculated *Hevea* with *Phytophthora* from *Hevea* he got the typical black vertical stripes of form A or " Streepjeskanker." Sporangia were presumably obtained from the diseased dark stripes on the tapping cut where they are found in abundance in Java. It is unfortunate that *Hevea Phytophthora* has not been inoculated on cacao, either by Petch or by Rutgers.

According to Rutgers[1] microscopic examination of sections of *Hevea* tissues attacked by canker shows the formation of secondary cambium outside the primary cambium round the brown dead cells. Mr. Bryce, Acting Botanist and Mycologist to the Government of Ceylon, kindly sent me spirit specimens of cankered *Hevea* bark from Ceylon. Sections from this bark showed the formation of secondary cambium surrounding the dead cells as observed by Rutgers in Java, while sections from renewing bark attacked by " Black Thread " in Burma do not show any formation of secondary cambium. These specimens of cankered bark from Ceylon also clearly showed the microscopic differences between canker and " Black Thread." Mr. Bryce also sent me specimens of diseased renewing bark from Ceylon. Not only in their external characters these specimens were identical with those of " Black Thread " disease of Burma, but microscopical examination also showed them to be identical. At the same time specimens of " Black Thread " on *Hevea* from Burma were sent to the Government Mycologist, Ceylon, with the request to let me know if a similar disease was known in Ceylon. Mr. Bryce took the trouble of examining these specimens and wrote to me that he had no hesitation in pronouncing the " Black Thread " disease of Burma to be the same as the one occurring on the tapping area in Ceylon where the disease is known variously

[1] Rutgers, A. A. L. *Hevea*-Canker, Dep. Landbouw Nijverheid en Handel, Meded. Afdeeling voor Plantenzeikten, No. 2, 1912, p. 5.

as "Bark Rot," "Decay of renewing bark," and sometimes as "Dieback," and this "Bark Rot," according to him, is capable of explanation on purely physiological grounds.[1]

From the above account it is clear that on *Hevea* there are two distinct forms of disease caused by *Phytophthora*, one causes canker in Ceylon, Borneo, Java and Sumatra, identical with the cacao canker; and it is significant that this *Hevea* canker does not cause much damage on plantations of *Hevea* only, but is decidedly more serious on mixed *Hevea* and cacao plantations. The other form causes black stripes on the tapping area. This is found in Borneo, Java and Sumatra, along with the former disease; and in Burma, Cochin and Travancore by itself. Furthermore, the decay of renewing bark, first recorded by Petch[2] in Ceylon, is due to the second form and not due to wet condition as supposed by him.

It seems clear that we have on *Hevea* two different species of *Phytophthora* causing two distinct kinds of diseases instead of one fungus causing two distinct symptoms of one disease. Of these two different species one is *Ph. Faberi* which causes *Hevea* canker identical with that of cacao as shown by the inoculation experiments of Petch and Rutgers; and the other species causes "Streepjeskanker" or "Black Thread" disease as seen from the inoculation experiments made by Rutgers in Java and by me in Burma.

This veiw of there being two diseases of *Hevea* stem caused by two species of *Phytophthora* is strengthened by inoculation experiments and by morphological study.

Fruits and cuttings of *Theobroma Cacao*, kindly furnished by Mr. C. D. Mahaluxmiwala, Superintendent, Municipal Gardens, Bombay, and by Mr. H. E. Houghton, Superintendent, Agri-Horticultural Gardens, Madras, were inoculated with pure cultures of *Phytophthora* taken from *Hevea* fruits in Burma. Four cacao fruits, one about one and a half inch long and the other three about four to five inches long, were inoculated either with zoospores or with vigorously growing mycelium from pure cultures. Two were inoculated through cuts made on the surface and the other two were inoculated on the unwounded surface. Though these fruits were kept in moist chambers for over a fortnight, there was absolutely no trace of the inoculation succeeding. Four

[1] Bryce, G. Report of the Acting Botanist and Mycologist. Trop. Agr., XLVII, No. 1, 1916, p. 29.

[2] Petch, T. Cacao and *Hevea* Canker. Circs. & Agri. Jour. Roy. Bot. Gard., Ceylon, V, No. 13, 1910, p. 160.

cuttings of cacao, the thickest as thick as a man's thumb, were also inoculated in a similar way as the fruits. These cuttings were stood in flower vases filled with water and they were then kept in moist chambers but the inoculations here also failed. Petch[1] having recorded *Artocarpus incisa* as being one of the hosts of *Ph. Faberi*, fruits and cuttings of this plant and of *Artocarpus integrifolia* were inoculated in the same way as those of *Theobroma Cacao;* they also gave the same negative results.

Coleman[2] has shown that very young seedlings of *Solanum melongena* and *Lycopersicum esculentum* between one and three inches high possessing two or three leaves can be successfully inoculated with *Ph. Faberi* from cacao fruits; seedlings of these plants which had not dropped their cotyledonous leaves were inoculated with vigorously growing mycelium from pure cultures. In every case the inoculation failed. Very small plants of potatoes also failed to take the inoculation. But successful infections were secured on seedlings of *Gilia* spp., *Clarkia* spp., *Salpiglossis* spp., and *Ricinus communis.* The former three garden plants have been known to serve as hosts for *Ph. omnivora* and *Ph. parasitica*, and *Clarkia* and *Salpiglossis* also for *Ph. Arecæ* and *Ph. Faberi.*

In the Philippines, Mendiola and Espino[3] have recently found a disease of fruits of *Carica papaya* caused by *Ph. Faberi*, and this fungus from cacao they have succeeded in inoculating on papaya fruits; but these fruits did not give successful infections when inoculated with the *Phytophthora* under study.

The conidiophores on the fruit in Burma burst through the epidermis in clusters, they are simple or occasionally branched, and extremely short or up to 102μ long. They at times are so small that the sporangia appear almost sessile on the epidermis. Petch does not give his measurements of *Ph. Faberi* on *Hevea* but quotes those given by von Faber[4] who has studied this disease on cacao and according to whom the sporangiophores measure 150—200μ. Sporangia of the Burma fungus are generally pear-shaped and not very variable in shape; on fruits and stems they measure $20{\cdot}7$—$35{\cdot}7 \times 15{\cdot}0$—$25{\cdot}5\mu$. In rare cases the extreme length was $44{\cdot}2\mu$ and breadth $29{\cdot}0\mu$. The

[1] Petch, T. Ceylon Administration Report, 1906, Roy. Bot. Gardens.

[2] Coleman, L. C. Diseases of the Areca Palm, I, Koleroga. Mycol. Ser. Bull. No. II, Dept. Agri., Mysore State, 1910, p. 80.

[3] Mendiola, N. and Espino, R. B. Some Phycomycetous Diseases of Cultivated Plants in the Philippines. The Philippine Agriculturist and Forester, V, No. 3, 1916, p. 67.

[4] Von Faber, F. C. Die *Phytophthora*—Fäule der Kakaofrüchte. Arb. Kais. Biol. Anst. Land-und Forstwirtschaft, VII, 1910, p. 200.

average of 50 measurements gives the length as 28·5μ and breadth as 20·4μ; the proportion of breadth to length being 100 : 140. Thus they are smaller than those of *Ph. Faberi* which measure 42—80 × 25—30μ according to von Faber. The zoospores of the Burma species measure 7·5—12·5 × 5·0—7·5μ (those of *Faberi* are not given), and the number of zoospores emitted from a single sporangium got from the fruits varies from 3—10 whereas von Faber has observed as many as 20 zoospores arising from a single sporangium. According to Rorer[1] sporangia of *Ph. Faberi* from cacao measure 30—60 × 21—30μ, usually 30—50 × 25—27μ and emit from 15—30 zoospores. What von Faber and Coleman call oospores are really resting conidia or chlamydospores similar to those found in *Ph. parasitica*, *Ph. Colocasiæ*, and *Ph. infestans*. They measure 22—45μ according to these authors and according to Rorer 30—50μ. Those of the Burma fungus are much smaller and measure 17—34μ in diameter.

Peters[2] has described a disease of *Hevea* fruits in the Cameroons caused by a *Phytophthora* but he considers its identity with *Ph. Faberi* to be doubtful. From his scanty account of the disease it is not possible to say with certainty whether it is similar to the one found on *Hevea* fruits in Burma. But judging from the measurement given by him it seems probable that the fruit disease in the Cameroons is allied to that found in Burma. The sporangia on the diseased fruits in Burma are slightly smaller than those on the diseased fruits in the Cameroons, where the proportion of breadth to length is 100 : 144, but those produced in pure cultures are similar in both the cases. Similarly the resting spore (called by Peters oospores) are bigger on the fruits in the Cameroons than those found in Burma but those produced in pure cultures are of the same size.

Remedial Measures.

In a previous paper[3] preventive measures to check the disease have been suggested, *viz.*, thinning out thickly planted areas, systematic removal of diseased fruits and stopping of tapping on trees attacked by "Black Thread." In Java, Rutgers[4] recommends the treating of the affected bark with a solution of 20% carbolineum plantarium every 5 days and of removing from

[1] Rorer, J. B. Pod-Rot, Canker and Chupon-Wilt of Cacao caused by *Phytophthora* sp. Bull. of Trinidad Dept. Agri., IX, No. 65, 1910, p. 91.

[2] Peters. Uber eine Fruchtfäule von *Hevea brasiliensis* in Kamerun. Ber. üb. d, Tätigkeit d. Kais. Biol. Anst. im Jahre 1911. Mitt. Kais. Biol. Anst. 1912, No. 12.

[3] Dastur, J. F. *loc. cit.*

[4] Rutgers, A. A. L. and Arens, P. *loc. cit.*, p. 9, and
Rutgers, A. A. L. and Dammerman, K. W. *loc. cit.*, p. 31.

the tapping round trees affected with "Streepjeskanker." According to McRae and Sundararaman[1] in Mundakayam (Travancore) the rot of renewing bark can be checked by putting with the thumb a thin smear of a mixture of tar and tallow over the affected portion. When this paper was in the press the author's Bulletin was reviewed in the Planters' Chronicle[2] in which it is stated that the "Black Thread" disease is exactly similar to "Bark Rot" of *Hevea* in South India and that it has been found that a combination of cessation of tapping on attacked trees with the application of a thin smear of a mixture of tar and tallow to the diseased spot has proved very effective. The mixture is applied with the finger and then rubbed with a small piece of gunny so as to get only a smear confined to the bark area attacked and its action appears to be two-fold. The tar acts as an antiseptic while the tallow forms a waterproof covering and thus deprives the fungus of the moisture so necessary for its growth and welfare. After the monsoon the treated areas gradually shed a thin scale of tar coated bark and expose a clean healthy surface beneath. Mr. Anstead, Deputy Director of Agriculture, Planting Districts, Madras, has very kindly called my attention to the following extract from the Minutes of a Meeting of the Ceylon Committee of Agriculture. "The Acting Government Mycologist has instituted a series of experiments with a view to prevent further development of the bark rot disease of *Hevea* rubber. All other trees under tapping experiments have had the newly tapped surface covered with a thin coating of a mixture made by boiling one ounce of sulphur in half a kerosine tin of water and adding equal parts of fresh cowdung and clay till a thick paste is obtained. A pinch of salt added will tend to keep the paste moist and prevent cracking and peeling off the trees. The object is to protect the exposed delicate cambium layer from sun and drying winds, as a precaution against bark rot and to encourage good bark renewal. This should be applied monthly during dry weather within a quarter of an inch of the tapping area."

With regard to this last method it is difficult to see how this monthly application within a quarter of an inch of the tapping cut will completely prevent bark rot or "Black Thread" as the infection generally begins just on the newly opened cut and very possibly the renewal of the bark on this cut will have commenced before it gets covered with the mixture and then the chances of its getting infected are considerably reduced. In South India this mixture has also proved beneficial but it is applied all over the tapped

[1] McRae, W. and Sundararaman, S. *loc. cit.*
[2] Anonymous. Bark Rot of *Hevea*. The Planters' Chronicle, XI, No. 31, 1916, p. 382.

area, when tapping ceases, as it does in some districts, on account of the dry weather; the bark renews quickly and well beneath this covering and the bark rot is reduced.

In those parts of Burma where the rainfall is not as heavy as in South India the writer found that merely not tapping diseased trees during the rains checked the progress of the disease, and therefore it seemed there was no necessity to apply any mixture which would control the disease, except perhaps in extremely wet districts, such as Mergui, where the application of a thin mixture of tar and tallow smeared over the diseased area in the manner described above should be effective. Covering the tapped surface with a mixture of clay, cowdung and sulphur as is done in South India may be tried.

PUSA,
May 8, 1916.

PHYTOPHTHORA ON *VINCA ROSEA*.

BY

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At Pusa (India) the latter part of May 1913 was wet, so also most of the month of June. During this period the weather remained cloudy, and the atmosphere was charged with a great deal of moisture. These were ideal conditions for parasitic fungi to flourish to the detriment of their host plants. One of the garden plants that suffered during this period, was *Vinca rosea* belonging to the *N. O. Apocynaceæ*.

Leaves, growing points, tender stems just below growing points, flowers and fruits were observed to damp off, to turn brown and then black. Microscopic examination showed the presence of a parasite of the genus *Phytophthora*. The disease was prevalent for about a fortnight only. It disappeared soon after the weather cleared up and bright sunshine once again flooded the gardens. Even when the weather was wet, if diseased plants were removed to a dry place, the disease made no headway and the plant dropped its diseased parts and brought forth new healthy shoots. The causal parasite has never been found to be of a virulent character. Healthy plants inoculated with pure cultures in the laboratory invariably gave negative results, except when the surrounding atmosphere was kept saturated with moisture, which condition was secured by covering the inoculated plants grown in pots with bell jars with an inner lining of blotting paper and keeping the pots in a basin of water. Under these conditions the effects of the inoculations were visible in about a couple of days by the inoculated parts, flowers, leaves, growing points, stem just underneath the growing point, and fruits, turning brown and then black as in nature. Mature stems could not be successfully inoculated even in such an atmosphere. Follicles, sterilized by washing in corrosive sublimate (1 in 1,000) for five minutes, and unsterilized follicles were placed in six sterilized tubes containing moist cotton plugs. Bits of agar medium containing living mycelium from a healthy culture were used in inoculating these follicles.

Similarly sterilized follicles were placed in water in watch glasses, and were kept in moist chambers under aseptic conditions. These follicles were inoculated by zoospores from the same culture. Those in the tubes did not take the inoculation, even though in many cases aerial mycelium was found growing from the bits of agar medium used for inoculating the follicles; while those left in water showed signs of successful inoculations in twenty-four hours by the rotting that had set in; an aerial growth of mycelium soon followed. These inoculation experiments sufficiently show the weak parasitism of the fungus on *Vinca rosea*. Perhaps this is the only strain as yet isolated from any species of *Phytophthora* having such a weak parasitism.

On diseased leaves, sporangia were formed on both the surfaces, borne on short or long sporangiophores (from 3·4 to over 375μ in length) and emerging as a rule singly through stomata; in rare cases, sporangiophores have been found to be branched; two or three emerging together from a single stoma have also been observed. The sporangiophore, in a few cases, has been found to make its way out by rupturing a guard cell. Sporangia are sometimes borne on such short stalks that they almost seem to be sessile. From petioles and stems sporangiophores emerge singly or in clusters through any part of the epidermis as in *Ph. parasitica* Dast.[1] Sporangia are generally pear-shaped, but often irregular ones have been found. The mycelium within the tissues is both inter and intra-cellular. Haustoria have not been observed.

This *Phytophthora* was easily taken in pure culture. Diseased leaves and follicles, washed with corrosive sublimate (1 in 1,000) for five minutes and then with sterilized water, were incubated and gave, after a few days, a woolly growth. From this pure cultures were obtained by inoculating tubes of Quaker-Oat agar; this medium was prepared as recommended by Pethybridge and Murphy.[2] Also seeds removed aseptically from diseased follicles similarly sterilized on the surface, were introduced in tubes containing nutrient agar and subsequently gave pure cultures of the fungus.

The growth of this fungus on artificial media is very similar to that of *Ph. parasitica*[1] on castor, and also the vegetative, asexual and sexual reproductive organs; therefore a detailed description is not needed.

1 Dastur, J. F., on *Phytophthora parasitica* nov. spec. *Mem. Dept. Agric. India, Bot. Ser.*, V, No. 4, 1913.

2 Pethybridge, G. H. and Murphy, P. A., On Pure Cultures of *Ph. infestans* de Bary, and the Development of Oospores. *Sc. Proc. Roy. Dub. Soc.*, XIII (N.S.), No. 36, 1913.

The thickening, commonly found on septa of *Ph. Colocasiæ* Rac.[1] and *Ph. parasitica* Dast. is usually wanting. Very often branches have been found arising through septa, growing for some distance within the empty cells outside the septa and then coming out by perforating the wall as in *Ph. parasitica* and *Fusarium tuberivorum* Wilcox and Link[2] (Fig. 2). Such branches have been observed to form sporangia outside the parent hypha.

Sporangia and zoospores agree in measurements with those of the castor fungus. The formation of secondary sporangia in the *Vinca* fungus is common. They are either stalked or sessile. Sessile secondary sporangia have always been found to arise from the papilla, but stalked ones arise not necessarily from this place.

Zoospores sown in water, after coming to rest, germinate in less than half an hour by giving out one or as many as four germ-tubes. The fungus upon castor has not hitherto been observed to give more than two germ-tubes. The germ-tube either grows into a thin hypha, branched or unbranched, or becomes swollen. The germinating zoospore, in the course of six to twenty-four hours, commonly bears a sporangium at the end of its germ-tube (Fig. 1). This mode of germination has been observed by Raciborski[3] in *Phytophthora Colocasiæ* and by me in *Ph. parasitica* on castor. The sporangia borne on germ-tubes are pear-shaped and measure $13—20 \times 10—15\mu$. They germinate either by discharging their zoospores, which are from 2 to 6 in number and as big as those produced by sporangia from nutrient media, or by giving rise to germ-tubes or to secondary sporangia.

Resting conidia resemble those of *Ph. parasitica* in all respects, except in size ; the former are smaller, measuring $10—42\mu$ in diameter.

According to Klebs,[4] *Oedogonium* can be readily induced to form antheridia by regulating light, amount of water and the nutrient quality of the medium used. It has not been found possible to induce the development of sexual organs of this fungus by any systematic method, for it is exceedingly difficult to determine the predisposing factors. Oospores were found first in one of the six French bean juice agar tubes and a fortnight later in another, all of which had been inoculated the same day with mycelium from a culture growing on Quaker-Oat agar. These six French bean juice agar tubes belonged

[1] Butler, E. J. and Kulkarni, G. S. Studies in *Peronosporaceæ*. *Mem. Dept. Agric. India, Bot. Ser.* V, No. 5, 1913.

[2] Wilcox, E. M., Link, G. K. and Pool, V. W. A dry rot of the Irish Potato tuber. *Nebraska Agri. Expt. Sta. Res. Bull.* No. 1, 1913.

[3] Raciborski, M. *Parasitische Algen und Pilze Java's* I, 1900.

[4] Klebs, G. *Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen*, 1896.

to the same batch. Evidently therefore there can hardly be any difference in the composition of their contents. Before they were inoculated they had

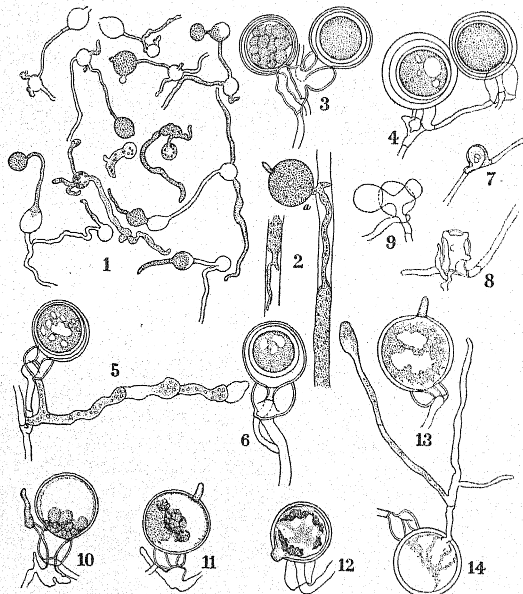

Fig. 1. Zoospores germinating and producing sporangia and secondary sporangia × 305.
Fig. 2. Branches arising through septa.
(*a*) shows the formation of a sporangium on such a branch × 305.
Fig. 3. Double antheridium × 557.
Fig. 4. Branched antheridium × 557.
Fig. 5. An oospore, the oogonium and antheridium of which arise from the same parent hypha.
The oogonium and antheridium are lateral in origin × 557.
Fig. 6. An oospore, the oogonial stalk arises laterally from the antheridial stalk × 557.
Fig. 7. An oogonium originating from within an antheridium × 557.
Fig. 8. An oogonium piercing an antheridium on its way out at several points × 557.
Fig. 9. An oogonium bifurcating within an antheridium × 557.
Fig. 10. An oogonium germinating vegetatively × 557.
Figs. 11—14. Germinating oospores × 557.
In Figs. 11, 13 and 14 the oospore wall has completely dissolved.
In Fig. 12 the oospore wall is partly dissolved and what is left of it is wavy in outline.

been placed in the same basket and after inoculation they were all in the same jar exposed to light. It is therefore difficult to understand why only two of these cultures formed oospores while the remaining four developed only sporangia and resting conidia. Subcultures were made on French bean juice agar, Oat juice agar, Quaker-Oat agar and Wheat juice agar from these cultures bearing oospores. Of these subcultures only one on Oat juice agar developed oospores and although over a couple of dozen cultures were made on Quaker-Oat agar from different sources still only one tube of this medium gave oospores. Many cultures on Oat juice agar produced oospores but their development had no relation to the parent cultures. Tubes inoculated with cultures producing oospores did not necessarily bear the sexual organs while transfers made from cultures on the same medium and from French bean juice agar cultures not bearing oospores occasionally produced them. Thus it is not easy to say what factor or factors stimulate the development of oospores. This discontinuous production of oospores differs from the result got by Pethybridge and Murphy[1] with *Ph. infestans* (Mont.) de Bary, where a culture once having commenced to form oospores, continues to do so without break in the subsequent transfers.

The development of oospores follows the method found almost simultaneously in five species of this genus, *viz., Ph. erythroseptica* Pethyb., *Ph. infestans* (Mont.) de Bary, *Ph. Phaseoli* Thaxt., *Ph. parasitica* Dast. and *Ph. Colocasiæ* Rac. Antheridia and oogonia are always produced embedded in the nutrient medium, and are as a rule borne on separate hyphæ, but in a few cases they have been found to be borne on a common stalk (Fig. 6).

The antheridium of the *Phytophthora* upon *Vinca* is identical with that of the castor parasite ; in certain cases branched and double antheridia (Figs. 4 and 3) were observed in the fungus upon *Vinca.*

Whenever it has been possible to trace clearly the oogonial stalk for some distance it has been found that, like the antheridial stalk, it has a lateral origin (Fig. 5). In a few cases the oogonium has been observed to be intercalar, so also the antheridium. The oogonium has also been found to arise from within the antheridium as in *Ph. parasitica* (Fig. 7). The tentative oogonial incept is at first thin-walled and is distinguishable from the vegetative branches of the hyphæ by its having dense and coarsely granular protoplasm ; when it comes in contact with an antheridium its apex as a rule swells before piercing the antheridial wall. It generally enters the antheridium somewhere at or near the base, as in the other species belonging to the " *infestans*-group. "

[1] Pethybridge, G. H., and Murphy, P. A. *loc. cit.*

The swollen or knob-like portion of the oogonial incept that is outside the antheridial incept may give out a sterile projection like the antheridium. In a few cases two oogonial incepts have been found to penetrate the same antheridium at two different points, but these oogonial incepts have never been found to mature; they were never observed to break through the antheridium. It is quite possible for more than one oogonium to be attracted towards a single antheridium and to make their way within it; but it is a question whether the antheridium would be able to fertilize more than one oogonium. The oogonial incept within the antheridium is club-shaped, grows within it and eventually bursts through it at some point. In an exceptional case the oogonial incept within the antheridium had made attempts to break through at four places by means of four projections three of which had succeeded in boring their way out (Fig. 8). In another case the oogonial incept within the antheridium bifurcated before leaving it and two branches made their way out by piercing the antheridial wall at two different points (Fig. 9). It seems improbable that these oogonia would have matured and produced oospores. After leaving the antheridium, the oogonial incept swells out into a globose body, the oogonium proper. The course of development of the oospore could not be observed. For the asexually formed sporangia to revert to the vegetative condition is common and cases have also been known in some species of *Pythium*, where the oogonium had also reverted to the vegetative condition. Thus Wahrlich[1] has observed oogonia, which, on being not fertilized, continue their growth vegetatively. Ward[2] has also made like observations. A similar case has been found in the fungus under study (Fig. 10). An oogonium in Oat juice agar, after making its way out from within the antheridium, had grown to its full size but the wall was still unthickened and uncoloured; it was almost empty of its protoplasmic contents, except the thin layer that lined the inside of the oogonial wall and the little mass that was at the base of the oogonium. Within the antheridium a lateral branch had grown out piercing the antheridial wall. Outside the antheridium it became septate and the portion beyond the septum had protoplasmic contents finely granulated and was thin-walled, like an ordinary hypha, while that below the septum was empty and slightly thicker, as thick as the oogonium from which it had arisen; it also contained a small cellulose ingrowth. The oogonium on failing to form an oospore had thus germinated vegetatively. The colour, thickness, and size of the oogonial wall is influenced by the medium

[1] Wahrlich, W. *Pythium* n. sp. *Ber. Deutsch. Bot. Ges.*, V, 1887.

[2] Ward, H. M. Observations on the genus *Pythium*. *Quart. Journ. Micros. Science*, XXIII (N. S.), 1883.

in which it is growing, as in *Phytophthora* on castor ; but very often on the same medium smooth and rough-walled oospores have been produced, the development of secondary thickening depending upon local conditions. In French bean juice agar the oogonium is very slightly yellow tinted, almost hyaline ; in Oat juice agar and Quaker-Oat agar it is honey-coloured ; in the latter medium of a lighter colour than in the former.

The size of the oospore, unlike that of the *Phytophthora* on castor, is also influenced by the medium in which it is grown. In French bean juice agar it varies from 14—18μ in diameter, extreme measurements being 11μ and 20μ and the average of 97 measurements being 15·8μ ; in Oat juice agar and in Quaker-Oat agar from 16—21μ in diameter, extreme measurements being 15μ and 23μ and the average of 57 measurements being 18·4μ ; the size of the oospores on these last two media closely agrees with that of oospores of the castor fungus. Generally the wall of the oospore is not very thick, but it seems that it is inversely proportional to the thickness of the surrounding oogonial wall. In French bean juice agar, it is slightly thicker than in Oat juice agar or Quaker-Oat agar. The oospore is hyaline in colour.

Attempts were made to germinate oospores in tap water and sterilized water taken from wayside pools but they failed, while a few of the many oospores from Oat juice agar sown in wet earth showed attempts at germination. It appears that the germination is preceded by the disappearance of the oil globule or globules and by the fine protoplasmic contents of the oospores turning coarser. The germination is accompanied by the complete or partial dissolution of the oospore wall (Figs. 11 to 14). When the oospore is just beginning to germinate its wall shows at times a zig-zag outline due to its unequal dissolution (Fig. 12), as observed by Pethybridge[1] in the germinating oospores of *Ph. erythroseptica* Pethyb. In one case the germ-tube had grown into a long branched hypha, the end of one of the branches being swollen as if it was going to form a sporangium (Fig. 14) ; but further growth did not take place as the hypha became empty of its contents. From the few cases observed it seems that the colour of the oogonium of the germinating oospore growing on Oat juice agar becomes lighter. Two oospores in an Oat juice agar tube were found to have produced short germ-tubes, one each. In both these cases the oospore wall had completely dissolved, and the oogonium was partly empty. In one a thin layer of protoplasm was lining the inside of the oogonial wall. No oil globules were found within the two germinating oospores and the contents were coarsely granular. As far as could be judged

[1] Pethybridge, G. H. Further observations on *Ph. erythroseptica* Pethyb. and on the disease produced by it in the potato plant. *Sc. Proc. Roy. Dub. Soc.*, XIV (N.S.), No. 10, 1914.

from the few oospores of the *Phytophthora* on *Vinca rosea*, that have been observed germinating, it appears that the mode of germination agrees, at least in essential points, with that of *Ph. erythroseptica* described minutely by Pethybridge.

On account of the peculiar mode of development of oospores, this fungus belongs to what Pethybridge[1] calls the "*infestans*-group." Of all the species of this group, the *Phytophthora* on *Vinca rosea* is most closely allied to *Ph. parasitica* Dast. on castor. Inoculation experiments were carried out to trace further the affinity between these two. From the very commencement of the study of this parasite it was found that, in order to get successful results, the inoculated plant, even if it be the original host, must be kept in an atmosphere saturated with moisture. Inoculated plants were, therefore, always kept in such an atmosphere as described on page 233. It may be noted that no such precautions were required with plants successfully inoculated by *Ph. parasitica*, and that the negative results of the inoculation of certain plants detailed below with the *Phytophthora* on castor have been obtained even when they had been tried under very moist conditions. Inoculations on living plants were in all cases made by means of zoospores from pure cultures.

The following table shows the results of various inoculation experiments :—

Name of host	Results of inoculation with *Phytophthora* on *Vinca*	Results of inoculation with *Phytophthora* on castor
Clarkia elegans. Seedlings in a pot ..		
Gilia nivalis and mixed species. Seedlings in a pot.		
Salpiglosus variabilis and mixed species. Seedlings in a pot.		
Schizanthus retusa and mixed species. Seedlings in a pot.	Positive	Positive
Ricinus communis. Seedlings in a pot ..		
Syringa vulgaris. Small plants.		
Vinca rosea. Mature plants		
Fruits of *Vinca rosea*	Positive	Negative

[1] Pethybridge, G. H. On the Rotting of Potato Tubers by a New Species of *Phytophthora* having a Method of Sexual Reproduction hitherto undescribed. *Sc. Proc. Roy. Dub. Soc.*, XIII (N. S.), No. 35, 1913.

Name of host	Results of inoculation with *Phytophthora* on *Vinca*	Results of inoculation with *Phytophthora* on castor
Fruits of *Ricinus communis*	Positive	Positive
Petunia sp. Seedlings in a pot	Positive	Negative
Martynia diandra. Mature plants		
These two hosts have been found in nature to be attacked by a *Phytophthora*.		
Solanum melongena. Young plants ..	Negative	Positive.
Solanum tuberosum. Young plants ..		
Lycopersicum esculentum. Young plants ..	Positive	Positive.
Living potato tubers (inoculated through wounds).	Positive (poor growth	Positive (copious growth).
Sterilized corms of *Colocasia antiquorum* ..	Positive	Negative.
Sterilized potatoes	Negative	Positive.
Sterilized ants		

In the author's opinion, these differences and those found from the study of pure cultures are not enough to justify the making of a new species, of the *Phytophthora* on *Vinca rosea*. Cumulative evidence shows that it is only a biologic variety of *Phytophthora parasitica* Dast. on castor.

SUMMARY.

1. A weak parasite belonging to the genus *Phytophthora* was found attacking *Vinca rosea* in May, 1913, under very wet climatic conditions.

2. Microscopic characters of this disease in *Vinca* are similar to those of *Ph. parasitica* Dast. on castor except that sporangia are borne on both the surfaces and that sporangiophores are smaller.

3. Asexual spores agree with those of *Ph. parasitica;* the chief differences are that resting conidia are smaller and zoospores produce as many as four germ-tubes while those of *Ph. parasitica* have not been observed to produce more than two.

4. The formation of oospores is identical with that of *Ph. parasitica.* The size of the oospore like that of the oogonium is influenced by the medium in which it grows. On certain media (Oat juice agar and Quaker-Oat agar) the measurements agree closely with those of *Ph. parasitica* from castor. From the few cases of the germination that have been observed it appears that the mode of germination is the same as that observed by Pethybridge in *Ph. erythroseptica* Pethyb.

5. Inoculation experiments show that there are some points of difference between the *Phytophthora* on castor and that on *Vinca.* The latter is distinctly weaker in parasitism than the former. Some of the hosts are common to both, while some which were attacked by the *Vinca* parasite resisted infection by that from castor.

6. It is concluded that the fungus is not a distinct species but only a biologic strain of *Ph. parasitica* Dast.